DOCUMENT RESUME

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IDENTIFIERS	Military Curriculum Project

ABSTRACT

This plan of instruction, lesson plans, and student materials (programed texts, workbooks, and study guides) for a secondary-postsecondary level course in engine mechanics is one of a number of military-developed curriculum packages selected for adaptation to vocational instruction and curriculum development in a civilian setting. It is the third of a four-part course (see Note for other sections) covering general vehicle mechanics, including inspection, maintenance, and repair. The plan of instruction suggests number of hours of class time devoted to each lesson in two blocks of instruction (Blocks IV and V), a total of 155 hours of instruction: (1) Tune-Up and Troubleshooting (4 lessons, 78.5 hours), including engine, mechanical, battery, ignition, fuel, lubrication, cooling, crankcase ventilating, anti-pollution, emission control, lighting, warning, and signal systems, and (2) Power Trains (9 lessons, 76.5 hours), including maintenance, troubleshooting, and repair. It also details criterion objectives and support materials needed. Lesson plans outline teaching steps. Student materials in Block IV include a workbook, handout, and three programed texts and in Block V a study guide with objectives, text, and review questions; a study guide/workbook with shop procedures; and seven programed texts.

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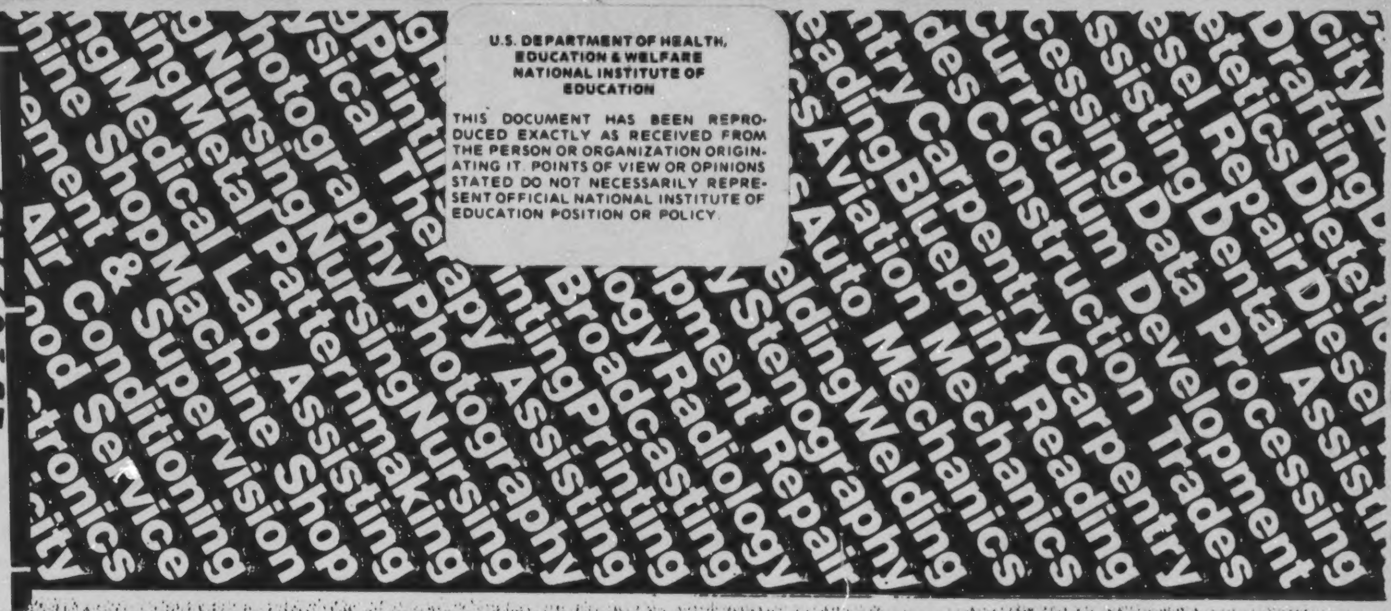

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Military Curricula for Vocational & Technical Education

General Purpose Vehicle Mechanic

Blocks IV & V, 8-11

CE 024 830

THE NATIONAL CENTER
FOR RESEARCH IN VOCATIONAL EDUCATION
THE OHIO STATE UNIVERSITY

This military technical training course has been selected and adapted by The Center for Vocational Education for "Trial Implementation of a Model System to Provide Military Curriculum Materials for Use in Vocational and Technical Education," a project sponsored by the Bureau of Occupational and Adult Education, U.S. Department of Health, Education, and Welfare.

MILITARY CURRICULUM MATERIALS

The military-developed curriculum materials in this course package were selected by the National Center for Research in Vocational Education Military Curriculum Project for dissemination to the six regional Curriculum Coordination Centers and other instructional materials agencies. The purpose of disseminating these courses was to make curriculum materials developed by the military more accessible to vocational educators in the civilian setting.

The course materials were acquired, evaluated by project staff and practitioners in the field, and prepared for dissemination. Materials which were specific to the military were deleted, copyrighted materials were either omitted or approval for their use was obtained. These course packages contain curriculum resource materials which can be adapted to support vocational instruction and curriculum development.

The National Center Mission Statement

The National Center for Research in Vocational Education's mission is to increase the ability of diverse agencies, institutions, and organizations to solve educational problems relating to individual career planning, preparation, and progression. The National Center fulfills its mission by:

- Generating knowledge through research
- Developing educational programs and products
- Evaluating individual program needs and outcomes
- Installing educational programs and products
- Operating information systems and services
- Conducting leadership development and training programs

FOR FURTHER INFORMATION ABOUT
Military Curriculum Materials
WRITE OR CALL
Program Information Office
The National Center for Research in Vocational Education
The Ohio State University
1960 Kenny Road, Columbus, Ohio 43210
Telephone: 614/486-3655 or Toll Free 800/848-4815 within the continental U.S. (except Ohio)

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Military Curriculum Materials for Vocational and Technical Education

Information and Field Services Division

The National Center for Research in Vocational Education

Military Curriculum Materials Dissemination Is . . .

an activity to increase the accessibility of military-developed curriculum materials to vocational and technical educators.

This project, funded by the U.S. Office of Education, includes the identification and acquisition of curriculum materials in print form from the Coast Guard, Air Force, Army, Marine Corps and Navy.

Access to military curriculum materials is provided through a "Joint Memorandum of Understanding" between the U.S. Office of Education and the Department of Defense.

The acquired materials are reviewed by staff and subject matter specialists, and courses deemed applicable to vocational and technical education are selected for dissemination.

The National Center for Research in Vocational Education is the U.S. Office of Education's designated representative to acquire the materials and conduct the project activities.

Project Staff:

Wesley E. Budke, Ph.D., Director
National Center Clearinghouse

Shirley A. Chase, Ph.D.
Project Director

What Materials Are Available?

One hundred twenty courses on microfiche (thirteen in paper form) and descriptions of each have been provided to the vocational Curriculum Coordination Centers and other instructional materials agencies for dissemination.

Course materials include programmed instruction, curriculum outlines, instructor guides, student workbooks and technical manuals.

The 120 courses represent the following sixteen vocational subject areas:

- Agriculture
- Aviation
- Building & Construction Trades
- Clerical Occupations
- Communications
- Drafting
- Electronics
- Engine Mechanics
- Food Service
- Health
- Heating & Air Conditioning
- Machine Shop
- Management & Supervision
- Meteorology & Navigation
- Photography
- Public Service

The number of courses and the subject areas represented will expand as additional materials with application to vocational and technical education are identified and selected for dissemination.

How Can These Materials Be Obtained?

Contact the Curriculum Coordination Center in your region for information on obtaining materials (e.g., availability and cost). They will respond to your request directly or refer you to an instructional materials agency closer to you.

CURRICULUM COORDINATION CENTERS

EAST CENTRAL
Rebecca S. Douglass
Director
100 North First Street
Springfield, IL 62777
217/782-0759

MIDWEST
Robert Patton
Director
1515 West Sixth Ave.
Stillwater, OK 74704
405/377-2000

NORTHEAST
Joseph F. Kelly, Ph.D.
Director
225 West State Street
Trenton, NJ 08625
609/292-6562

NORTHWEST
William Daniels
Director
Building 17
Airdustrial Park
Olympia, WA 98504
206/753-0879

SOUTHEAST
James F. Shill, Ph.D.
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Mississippi State University
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Mississippi State, MS 39762
601/325-2510

WESTERN
Lawrence F. H. Zane, Ph.D.
Director
1776 University Ave.
Honolulu, HI 96822
808/948-7834

ERAL PURPOSE VEHICLE MECHANIC, BLOCKS IV & V

Classroom Course

Developed by:
United States Air Force

Development and Review Dates:

November 6, 1975

[illegible]

[illegible]

Occupational Area:
Engine Mechanics

Target Audiences:
Grades 11-adult

Print Pages:
526

Cost:
$10.75

Availability:
Military Curriculum Project, The Center for Vocational Education, 1960 Kenny Rd., Columbus, OH 43210

Contents:	Type of Materials:	Lesson Plans:	Programmed Text:	Student Workbook:	Handouts:	Text Materials:	Audio-Visuals:	Instructional Design:	Performance Objectives:	Tests:	Review Exercises:	Additional Materials Required:	Type of Instruction:	Group Instruction:	Individualized:	
				No. of pages												
Block IV – *Tune-Up and Troubleshooting*		●	●	76		★	★		●			★		●	●	
Block V – *Power Trains*		●	●	24		●	★		●			★		●	●	

★ Materials are recommended but not provided.

Expires July 1, 1978

Course Description:

This section is the third of a four-part course covering general vehicle mechanics. The entire course covers inspecting, servicing, testing, adjusting, troubleshooting, and repairing automotive general purpose vehicles; gasoline engine tune-up and repair; manual and automatic transmission replacement and adjustment; lubrication system servicing and repair; cooling system servicing; power train repair; front end steering system adjustment and repair; brake system adjustment and repair; warning and lighting system repair; hydraulic control repair; air conditioning system servicing; corrosion control and preparation of vehicles for climatic conditions and shipment. This section of the course contains two blocks of instruction covering 155 hours.

Block IV – *Tune-Up and Troubleshooting* contains four lessons covering 78.5 hours of instruction. The lesson topics and respective hours follow:

Field Methods of Troubleshooting Engine Systems (24 hours)
Scientific Tune-Up of Mechanical, Battery, Ignition, Fuel, Lubrication Cooling and Crankcase Ventilating System (16 hours)
Tune-Up and Troubleshooting Engine Mechanical, Fuel, Ignition, Anti-Pollution, and Emmission Control Systems Using Diagnostic Test Equipment (24 hours)
Troubleshoot, Diagnosis, and Repair of Vehicle Lighting, Warning, Signal Systems, and Headlight Testing (14.5 hours)

Block V – *Power Trains* contains nine lessons covering 76.5 hours of instruction.

Clutches, Standard Transmission and Power Takeoff (11 hours)
Clutch and Transmission Removal and Replacement (8 hours)
Transfer Case, Propeller Shafts, Center Bearing, and Universal Joints (3 hours)
Conventional and Anti-Spin Differentials, Front and Rear Driving Axles (16 hours)
Principles of Automatic Transmissions (8 hours)
Mechanical Operation and Disassembly of Torque-Flite Transmissions and Selected Components (8 hours)
Hydraulic Operation and Repair of Subassemblies of Torque-Flite Transmissions (8 hours)
Reassembly and Troubleshooting of Torque-Flite Transmissions (8 hours)
General Automatic Transmission Maintenance Procedures (6.5 hours)

This course contains both teacher and student materials. Printed instructor materials include lesson plans outlining the teaching steps and a plan of instruction detailing units of instruction, criterion objectives, duration of the lessons, and support materials needed. In Block IV student materials consist of a workbook on tune-up and troubleshooting procedures; three programmed texts on Clayton Chassis dynamometer, lighting systems, and the Weaver headlight tester; and one handout on air system diagnosis. In Block V student materials consist of one study guide with objectives, text, and review questions; a study guide/workbook with shop procedures; and seven programmed texts on automatic transmissions, clutch principles, standard transmissions, power takeoff, drive train components, front and rear driving axles and anti-spin differential.

Several military manuals and commercially produced texts are referenced, but not provided. Audiovisuals suggested for use with the entire course include 53 transparencies, 10 films, and 205 slides. This section used in conjunction with the remaining three sections provides comprehensive coverage of vehicle inspection, maintenance and repair. Some documents can be used individually as sub-units, remedial, or individualized study, and the entire course can be used in a group instructional setting or adapted for individual use.

GENERAL PURPOSE VEHICLE MECHANIC, BLOCKS IV AND V

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- Weaver Headlight Tester - Programmed Text Page 199
- Lighting, Signal, and Warning Systems - Programmed Text Page 246

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3.

PLAN OF INSTRUCTION	COURSE TITLE General Purpose Vehicle Repairman - Part I

BLOCK TITLE

Tune-Up and Troubleshooting

UNITS OF INSTRUCTION AND CRITERION OBJECTIVES 1	DURATION (HOURS) 2	SUPPORT MATERIALS AND GUIDANCE 3
1. **Field Methods of Troubleshooting Engine Systems**	24 (18/6) Day 26,27 28	Column 1 Reference — STS Reference 1a — 3, 9, 12c, 14c 1b — 3, 9, 15c 1c — 3, 9, 11d Instructional Materials 3ABR47330-WB-401, Field Methods of Troubleshooting Engine Systems Dynamometer Operator Training Handbook Audio Visual Aids Charts - Ignition Components Training Equipment Trainers, Engines (1): 61-2785, Engine, Ford, V-8 60-2761, Engine, GMC 6 Cyl 60-2759, Engine, IHC 6 Cyl 61-2781, Engine, Chevrolet 6 Cyl 61-2800, Engine, Valiant 6 Cyl Mechanic's Common Handtools (1) Training Methods Discussion/Demonstration (9 hrs) Performance (9 hrs) Outside Assignment (6 hrs) Instructional Environment/Design Classroom (9 hrs) Laboratory (9 hrs) Instructional Guidance Discuss safety and troubleshooting procedures and demonstrate field methods of troubleshooting. Assign each student an engine with troubles induced and supervise him while he isolates and corrects the
a. Given engine trainer with trouble inducing devices installed, tools, workbook, with test equipment denied, and practicing personnel and equipment shop safety, use visual, auditory, and operational means, check, troubleshoot, and correct malfunctions in the starting and ignition systems. Follow the procedures outlined in the workbook.	(6)	
b. Given engine trainer with trouble inducing devices installed, tools, workbook, with test equipment denied, and practicing personnel and equipment shop safety, using visual, auditory, and operational means, check, troubleshoot, and correct malfunctions in the fuel-air systems. Follow the procedures outlined in the workbook.	(6)	
c. Given engine trainer with trouble inducing devices installed, tools, workbook, with test equipment denied, and practicing personnel and equipment shop safety, using visual, auditory, and operational means, check, troubleshoot, and correct malfunctions in the mechanical systems. Follow the procedures outlined in the workbook.	(6)	

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PLAN OF INSTRUCTION (Continued)

UNITS OF INSTRUCTION AND CRITERION OBJECTIVES 1	DURATION (HOURS) 2	SUPPORT MATERIALS AND GUIDANCE 3
		malfunctions. Point out and correct errors on the spot. Ensure that all safety procedures are followed. Stress energy and material conservation.
✓ 2. Scientific Tune-Up of Mechanical, Battery, Ignition, Fuel, Lubrication, Cooling, and Crankcase Ventilating Systems a. Provided engine trainer, tools, equipment, engine analyzer, TOs, workbook, following all safety precautions, use visual, auditory, operational means, and test equipment, to check starting, ignition, mechanical, and fuel-air systems IAW TOs and workbook.	16 (12/4) Day 29,30 (12)	**Column 1 Reference** 2a — **STS Reference** 3, 4d, 9, 11d, 12c, 14c, 15c **Instructional Materials** 3ABR47330-WB-402, Scientific Tune-Up of Mechanical, Battery, Ignition, Fuel, Lubrication, Cooling, and Crankcase Ventilation Systems 3ABR47330-SG-402, Crankcase and Exhaust Emission Systems ~~3ABR47330-SG-402A, Evaporative [illegible] Controls~~ TO 36A2-4-4-2, GMC Maintenance Manual TO 33D6-3-4-1, UDT Dynamometer Operator Training Handbook TO 33D6-3-6-1, Dist Advance Tester TO 36A2-2-1422 ~~TO 36A2-2-13-2~~, International Engine TO 36A2-3-12-2, Ford Engine (292V-8) TO 36A2-4-22-2, Chevrolet (250-6) TO 36A2-5-6-2, Chrysler (Slant 6) **Training Equipment** Trainers, Engines (1): 61-2785, Engine, Ford, V-8 60-2761, Engine, GMC 6 Cyl 60-2759, Engine, IHC 6 Cyl 61-2781, Engine, Chevrolet 6 Cyl 61-2800, Engine, Valiant 6 Cyl Mechanic's Common Handtools (1) Special Tools (1) Gauges (1) Engine Analyzer (2) Distributor Advance Tester (5) **Training Methods** Discussion/Demonstration (5 hrs) Performance (7 hrs) Outside Assignment (4 hrs)

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PLAN OF INSTRUCTION (Continued)

1 UNITS OF INSTRUCTION AND CRITERION OBJECTIVES	2 DURATION (HOURS)
3. Tune-Up and Troubleshooting Engine Mechanical, Fuel, Ignition, Anti-Pollution, and Emission Control Systems Using Diagnostic Test Equipment	24 (18/6) Day 31,32, 33
a. Given tools, vehicle, chassis dynamometer, TOs, and practicing automotive personnel and equipment shop safety, use visual, auditory, operational means, and test equipment to check mechanical, ignition, and fuel-air systems IAW TO.	(6)
b. Given tools, engine trainer, engine analyzers, TOs, and practicing all safety precautions, use visual, auditory, operational means, and test equipment to check mechanical, ignition, and fuel-air systems IAW TO.	(6)
c. Given workbook and engine trainers, determine procedures for inspection, maintenance, and repair of anti-pollution and emission control systems. Follow procedures outlined in workbook.	(6)

3 SUPPORT MATERIALS AND GUIDANCE

Instructional Environment/Design
Classroom (5 hrs)
Laboratory (7 hrs)

Instructional Guidance
Discuss procedures of scientific tune-up applied to the mechanical, electrical, and fuel systems. Include discussion of shop safety practices and demonstrate the use and care of test equipment. Assign each student an engine trainer to perform troubleshooting, isolation, and repair of malfunctions with the use of proper TOs. Maintain close supervision and point out and correct errors on the spot.

Column 1 Reference	STS Reference
3a	3, 4d, 11d, 14c, 15c
3b	3, 4d, 11d, 14c, 15c
3c	3, 4d, 10c

Instructional Materials
3ABR47330-PT-403, Clayton Chassis Dynamometer
3ABR47330-WB-403, Tune-Up and Troubleshooting Using Diagnostic Test Equipment (Simpson Universal Engine Analyzer)
TO 36A2-4-20-2, 1968 Chevrolet Chassis Service Manual
TO 36A2-5-2-22, Dodge Truck Service Manual
TO 33D6-3-10-1, Operation and Service Instructions Vehicle Chassis Dynamometer
TO 33D6-3-14-1, Instruction and P/B Universal Engine Analyzer
Dynamometer Operator Training Handbook
TO 36A2-3-8-2, Ford Shop Manual
~~TO 33A6-3-6-1~~ TO 33D6-3 16-1
TO ~~36A2-2-13-2~~ 36A 2-2-1-122
TO 36A2-3-12-2
TO 36A2-3-14-2, /68 Ford
TO 36A2-4-17-2, 67 Chev
TO 36A2-4-22-2, 69 Chev
TO 36A2-5-6-2

3ABR47330-SG-402 Crankcase and Exhaust Emission Systems
3ABR47330-SG-402A-Evaporative Emission Controls

Audio Visual Aids
Charts - Vehicle Emission Control
Slides, Vehicle Emission Control

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PLAN OF INSTRUCTION (Continued)

UNITS OF INSTRUCTION AND CRITERION OBJECTIVES 1	DURATION (HOURS) 2	SUPPORT MATERIALS AND GUIDANCE 3
		Training Equipment Trainers, Engines (1): 61-2785, Engine, Ford, V-8 60-2761, Engine, GMC 6 Cyl 60-2759, Engine, IHC 6 Cyl 61-2781, Engine, Chevrolet 6 Cyl 61-2800, Engine, Valiant 6 Cyl Mechanic's Common Handtools (1) Vehicle (2) Vehicle Chassis Dynamometer (10) Engine Analyzer (2) Distributor Advance Tester (5) **Training Methods** Discussion/Demonstration (6.5 hrs) Performance (11.5 hrs) Outside Assignment (6 hrs) **Instructional Environment/Design** Classroom (6.5 hrs) Laboratory (11.5 hrs) **Instructional Guidance** Discuss safety operation of test equipment and demonstrate how the equipment is used. Assign each student a vehicle and rotate the projects to be performed. Supervise the student and point out any errors and correct them on the spot. Use PT for outside assignment.
✓ 4. Troubleshoot, Diagnosis, and Repair of Vehicle Lighting, Warning, Signal Systems, and Headlight Testing	14.5 (10.5/4) Day 34,35	**Column 1 Reference** — **STS Reference** 4a — 16a 4b — 3, 9, 16c 4c — 3, 9, 16b 4d — 3, 9, 10b
a. Without references, identify basic facts relative to the function and operation of lighting, warning, and signal systems with 70% accuracy.	(3.5)	**Instructional Materials** 3ABR47330-WB-404, Troubleshooting, Diagnosis, and Repair of Lighting, Warning, and Signal Systems and Headlight Testing

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PLAN OF INSTRUCTION (Continued)

1 UNITS OF INSTRUCTION AND CRITERION OBJECTIVES	2 DURATION (HOURS)	3 SUPPORT MATERIALS AND GUIDANCE
b. Provided with tools, equipment, testers, vehicle, and practicing all safety precautions, interpret circuits, schematics, and diagrams, and use visual, operational means, and test equipment to check electrical systems, following the procedures outlined in PT.	(3)	3ABR47330-WB-404A, Troubleshooting, Diagnosis, and Repair of Lighting, Warning, and Signal Systems and Headlight Testing (Headlight Tester) 3ABR47330-WB-404B, Troubleshooting, Diagnosis, and Repair of Lighting, Warning, and Signal Systems and Headlight Testing (AC Headlight Aimer) 3ABR47330-PT-404, Lighting, Signal, and Warning Systems 3ABR47330-PT-404B, Weaver Headlight Tester TO 36A2-3-14-2-1 TO 36A2-4-17-2 Audio Visual Aids Films: TVL-472A, Weaver Headlight Tester TVL-472B, AC Headlight Tester Training Equipment Mechanic's Common Handtools (1) Special Tools (1) Voltmeter (1) Ammeter (1) Continuity Lamp (1) Soldering Equipment (1) Terminal Kit (4) Battery Hydrometer (2) Vehicle (2) AC Type H Headlight Aimer (2) Weaver Headlight Tester-Aimer (2) Training Methods Discussion/Demonstration (4.5 hrs) Performance (6 hrs) Outside Assignment (4 hrs) Instructional Environment/Design Classroom (4.5 hrs) Laboratory (6 hrs)
c. Given workbook, tools, equipment testers, and vehicle, and practicing automotive personnel and equipment shop safety, check and repair lighting, warning and signal systems, and check and adjust headlights following the procedures outlined in the workbook.	(3)	
d. Given tools, test equipment, vehicle, and practicing all safety precautions, repair or service vehicle safety accessories IAW manufacturer's specifications.	(1)	

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PLAN OF INSTRUCTION (Continued)

1 UNITS OF INSTRUCTION AND CRITERION OBJECTIVES	2 DURATION (HOURS)	3 SUPPORT MATERIALS AND GUIDANCE
		Instructional Guidance Discuss functional and operation of electrical systems and demonstrate the various types. Use applicable test equipment to check system operation. Assign each student a vehicle to troubleshoot and adjust headlights. Supervise him closely as he performs the tasks, correcting errors immediately.
5. Measurement Test and Test Critique	1.5 Day 35	

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PLAN OF INSTRUCTION	COURSE TITLE General Purpose Vehicle Repairman - Part I
BLOCK TITLE Power Trains	

UNITS OF INSTRUCTION AND CRITERION OBJECTIVES 1	DURATION (HOURS) 2	SUPPORT MATERIALS AND GUIDANCE 3
1. Clutches, Standard Transmission, and Power Takeoff	11 (9/2) Day 36,37	**Column 1 Reference** — **STS Reference** 1a — 17a 1b — 3, 4d, 9, 17b
a. Without references, identify basic facts and terms relative to principles of operation, function, and relationship of power trains and components with 70% accuracy.	(4)	**Instructional Materials** 3ABR47330-SG-501, Clutches, Standard Transmission and Power Takeoff 3ABR47330-PT-501, Clutch Principles 3ABR47330-PT-501A, Standard Transmission 3ABR47330-PT-501B, Power Takeoff TO 36A2-3-6-2, Ford E-100 Maintenance Manual TO 36A2-3-8-2, Ford F-100-800 Maintenance Manual TO 36A2-4-17-2, Chevrolet Service Manual
b. Provided with technical publications, bench items, tools, and equipment and applying automotive personnel and equipment shop safety, repair or service power trains and components IAW the technical order.	(5)	**Audio Visual Aids** Film: TF 1-4047F, Automotive Transmission Charts - Clutches and Transmissions Film: CFL 0301I, ABC's of Automotive Chassis **Training Equipment** Trainers: 60-2528, M-35 Truck Transmission (10) 60-2534, Trans Case M-35 Cargo Truck (10) Mechanic's Common Handtools (1) Special Tools (1) Bench Items: Clutch (10) Three-Speed Standard Transmission (2) Power Takeoff (4) **Training Methods** Discussion/Demonstration (4 hrs) Performance (5 hrs) Outside Assignment (2 hrs) **Instructional Environment/Design** Classroom (4 hrs)

PLAN OF INSTRUCTION NO. 3ABR47330	DATE 2 January 1975	BLOCK NO. V	PAGE NO. 27

PLAN OF INSTRUCTION (Continued)

1 UNITS OF INSTRUCTION AND CRITERION OBJECTIVES	2 DURATION (HOURS)	3 SUPPORT MATERIALS AND GUIDANCE
		Laboratory (5 hrs) **Instructional Guidance** Discuss purpose, constructional features, and operating principles of power train units and point out their relative location on the vehicle. Assign each student a unit and supervise closely while he/she performs the required tests. Rotate the students so that each student works on each unit. Point out and correct errors on the spot. Use PTs for outside assignment. Stress energy and material conservation.
✓ 2. Clutch and Transmission Removal and Replacement a. Supplied with tools and equipment, technical orders, vehicles, and observing automotive personnel and equipment shop safety, remove, repair, and replace clutch and transmission IAW the technical publication. b. Given vehicles, tools, and equipment, technical publications, and practicing automotive personnel and equipment shop safety, use visual and operational means to check the clutch and transmission IAW the technical order.	8 (6/2) Day 37,38	**Column 1 Reference** — **STS Reference** 2a — 3, 4d, 9, 17b 2b — 3, 4d, 9, 17c **Instructional Materials** 3ABR47330-SG-502, Clutch and Transmission Removal and Replacement TO 36A2-3-6-2 TO 36A2-3-8-2 TO 36A2-4-17-2 **Audio Visual Aids** Charts - Clutches **Training Equipment** Mechanic's Common Handtools (1) Special Tools (1) Transmission Jacks (1) Vehicles (2) **Training Methods** Discussion/Demonstration (1.5 hrs) Performance (4.5 hrs) Outside Assignment (2 hrs) **Instructional Environment/Design** Classroom (1.5 hrs) Laboratory (4.5 hrs)

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PLAN OF INSTRUCTION (Continued)

UNITS OF INSTRUCTION AND CRITERION OBJECTIVES 1	DURATION (HOURS) 2	SUPPORT MATERIALS AND GUIDANCE 3
		Instructional Guidance Discuss purpose, function, operating principles, and procedures for removal and installation. Demonstrate various methods and techniques used in performing maintenance on these components. Assign each student a power takeoff or transmission and supervise him closely while he disassembles, inspects, repairs, as required, and reassemble the unit.
✓ 3. Transfer Case, Propeller Shafts, Center Bearings, and Universal Joints a. Without reference, identify terms and basic facts relative to principles of operation, function, and relationship of transfer case, propeller shafts, center bearings, and universal joints with 70% accuracy.	3 Day 38	**Column 1 Reference** 3a **STS Reference** 17a **Instructional Materials** 3ABR47330-SG-503, Transfer Case, Sprag Units, Propeller Shafts, Center Bearings, Universal Joints and Winch 3ABR47330-PT-503, Drive Train Components TO 36A2-5-2-22, Dodge Truck Service Manual TO 36A2-5-2-62, Dodge Truck Service Manual **Audio Visual Aids** Charts - Drive-Line Components **Training Equipment** Trainers: 60-2533, Trans Case M-135 Cargo Trainer (10) 61-2829, Trans Assembly (10) 58-2297, Winch (4) 59-2448, Universal Joint (10) Bench Items: Transfer Case (10) Sprag Unit (10) Propeller Unit (10) Center Bearings (10) Universal Joints (10) **Training Methods** Discussion/Demonstration (3 hrs)

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PLAN OF INSTRUCTION (Continued)

1 UNITS OF INSTRUCTION AND CRITERION OBJECTIVES	2 DURATION (HOURS)	3 SUPPORT MATERIALS AND GUIDANCE
		Instructional Environment/Design Classroom (3 hrs) **Instructional Guidance** Discuss purpose, constructional features, and operating principles of power train units and point out their relative location on the vehicle.
✓ 4. Conventional and Anti-Spin Differentials, Front and Rear Driving Axles	16 (12/4) Day 39,40	**Column 1 Reference** — **STS Reference** 4a — 17a 4b — 3, 4d, 9, 17b 4c — 3, 4d, 9, 17c
a. Without references, identify basic facts and terms relative to principles of operation, function, and relationship of conventional and anti-spin differentials, front and rear driving axles with 70% accuracy.	(6)	**Instructional Materials** 3ABR47330-PT-504, Front and Rear Driving Axles 3ABR47330-PT-504A, Anti-Spin Differential
b. Supplied with bench items, tools, and equipment, technical publications, and using automotive personnel and equipment shop safety, repair or service conventional and anti-spin differentials, front and rear driving axles IAW the technical order.	(4)	3ABR47330-WB-504, Conventional and Anti-Spin Differential and Front Driving Axle 3ABR47330-SG-504, Conventional and Anti-Spin Differential and Front Driving Axle TO 36A-1-411, M-37 Truck Operation and Service Manual TO 36A2-5-22, 1964 Dodge Series Shop Manual TO 36A2-5-2-62, Dodge Truck Service Manual
c. Provided with tools and equipment, technical orders, bench items, and applying automotive personnel and equipment shop safety, use visual, operational means, and test equipment to check conventional and anti-spin differentials, front and rear driving axles IAW technical publications.	(2)	**Audio Visual Aids** Charts - Front and Rear Driving Axles **Training Equipment** Mechanic's Common Handtools (1) Special Tools (1) Dial Indicator (1) Trainers: 55-0744, Differentials (10) 66-3291, Rear Axle Assembly (10) 59-2431, Axle Assembly (10) Bench Items: Front-Driving Axle Assembly (2) Conventional Differential Assembly (2) Anti-Spin Differential Assembly (2) Vehicles (2)

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PLAN OF INSTRUCTION (Continued)

UNITS OF INSTRUCTION AND CRITERION OBJECTIVES 1	DURATION (HOURS) 2	SUPPORT MATERIALS AND GUIDANCE 3
		Training Methods Discussion/Demonstration (6 hrs) Performance (6 hrs) Outside Assignment (4 hrs) **Instructional Environment/Design** Classroom (6 hrs) Laboratory (6 hrs) **Instructional Guidance** Discuss purpose, constructional features, and operating principles of conventional and anti-spin differentials, front and rear driving axles. Assign each student a unit to work on and supervise him closely as he performs the required tasks. Rotate students so that each works on all units. Point out and correct errors on the spot. Use PT for outside assignment.
✓ 5. Principles of Automatic Transmissions a. Without references, identify basic facts and terms relative to terminology, planetary gears, and hydraulic principles of automatic transmissions. Students will apply them to selected functions and operations of a simple two-speed automatic transmission with 70% accuracy.	8 (6/2) Day 41	**Column 1 Reference** 5a **STS Reference** 17a **Instructional Materials** 3ABR47330-SG-505, Principles of Automatic Transmissions 3ABR47330-PT-505, Automotive Transmissions **Training Equipment** Trainer: 59-2469, Simple Planetary Gear Set (10) Misc Bench Items **Training Methods** Discussion/Demonstration (6 hrs) Outside Assignment (2 hrs) **Instructional Environment/Design** Classroom (6 hrs) **Instructional Guidance** Discuss constructional features and demonstrate operating principles of related components that make up automatic transmissions. Stress all safety precautions. Stress energy and material conservation.

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PLAN OF INSTRUCTION (Continued)

UNITS OF INSTRUCTION AND CRITERION OBJECTIVES 1	DURATION (HOURS) 2	SUPPORT MATERIALS AND GUIDANCE 3
6. Mechanical Operation and Disassembly of Torque-Flite Transmissions and Selected Components a. Without references, identify basic facts and terms relative to the principles of operation of torque converters and planetary gear trains and provided with questions, the students will select the response that identifies selected principles of operation of torque converters and torque-flite transmissions with 70% accuracy. b. Provided with tools, equipment, and bench items, while adhering to appropriate safety practices, disassemble torque-flite transmission IAW appropriate technical publications.	8 (6/2) Day 42	**Column 1 Reference** — **STS Reference** 6a — 17a 6b — 3, 4d, 9, 17b **Instructional Materials** 3ABR47330-SG-506, Principles of Operation and Maintenance of Torque-Flite Automatic Transmissions TO 36A2-5-14-2, 1972 Chrysler Service Manual **Audio Visual Aids** Charts - Torque-Flite Transmission **Training Equipment** Bench Items: Torque-Flite Automatic Transmissions (2) Mechanic's Common Handtools (1) Special Tools (2) **Training Methods** Discussion/Demonstration (3.5 hrs) Performance (2.5 hrs) Outside Assignment (2 hrs) **Instructional Environment/Design** Classroom (3.5 hrs) Laboratory (2.5 hrs) **Instructional Guidance** Discuss the operating principles of torque converters and torque-flite transmissions. Assign students to bench item transmission and supervise closely to ensure adherence to procedures while they assemble transmission. Stress all safety precautions. Stress energy and material conservation.

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PLAN OF INSTRUCTION (Continued)

UNITS OF INSTRUCTION AND CRITERION OBJECTIVES 1	DURATION (HOURS) 2	SUPPORT MATERIALS AND GUIDANCE 3
7. Hydraulic Operation and Repair of Subassemblies of the Torque-Flite Transmission a. Without reference, identify basic facts and terms relative to the hydraulic operation in the torque-flite transmission with 70% accuracy. b. Supplied with bench items, tools, equipment, and technical publications, and using appropriate safety practices, disassemble, inspect, and reassemble subassemblies of the torque-flite transmission IAW technical publications.	8 (6/2) Day 43	**Column 1 Reference** — **STS Reference** 7a — 17a 7b — 3, 4d, 9, 17b **Instructional Materials** 3ABR47330-SG-506, Principles of Operation and Maintenance of Torque-Flite Transmission TO 36A2-5-14-2 **Audio Visual Aids** ~~Charts - Torque-Flite Transmission~~ **Training Equipment** Bench Item: Torque-Flite Transmission (2) Mechanic's Common Handtools (1) Special Tools (2) **Training Methods** Discussion/Demonstration (2 hrs) Performance (4 hrs) Outside Assignment (2 hrs) **Instructional Environment/Design** Classroom (2 hrs) Laboratory (4 hrs) **Instructional Guidance** Discuss the operation and relationship of the hydraulic system components. Allow students to disassemble, inspect, and reassemble the components. Stress energy and material conservation.
8. Reassembly and Troubleshooting of Torque-Flite Transmissions a. Provided with tools, equipment, bench items, technical publications, and observing appropriate safety precautions,	8 (6/2) Day 44	**Column 1 Reference** — **STS Reference** 8a — 3, 4d, 9, 17b 8b — 3, 4d, 9, 17a **Instructional Materials** 3ABR47330-SG-506, Operation and Maintenance of Torque-Flite Transmission TO 36A2-5-14-2

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PLAN OF INSTRUCTION (Continued)

1 UNITS OF INSTRUCTION AND CRITERION OBJECTIVES	2 DURATION (HOURS)	3 SUPPORT MATERIALS AND GUIDANCE
assemble torque-flite transmissions IAW technical orders. b. Provided with technical publications, transmission malfunction symptoms, the student will apply troubleshooting procedures to isolate malfunctions and make recommended corrective actions with 70% accuracy.		Training Equipment Bench Items: Torque-Flite Transmissions (2) Mechanic's Common Handtools (2) Special Tools (2) Training Methods Discussion/Demonstration (2 hrs) Performance (4 hrs) Outside Assignment (2 hrs) Instructional Environment/Design Classroom (2 hrs) Laboratory (4 hrs) Instructional Guidance Students will assemble transmissions in accordance with TO and instructor will supervise closely to ensure adherence. Present operational malfunctions for students to isolate. Stress all safety precautions. Stress material and energy conservation.
✓ 9. General Automatic Transmission Maintenance Procedures a. Provided with tools, equipment, vehicles, engine trainers w/transmissions, and observing appropriate safety practices, use visual and operational means to perform leak detection, band and linkage adjustments, vacuum control unit checks, and determine fluid change procedures on automatic transmissions IAW technical publications.	6.5 (4.5/2) Day 45	Column 1 Reference 9a STS Reference 3, 4d, 9, 17b, 17c Instructional Materials 3ABR47330-SG-506, Operation and Maintenance of Torque-Flite Transmissions TO 36A2-2-14-2 TO 36A2-3-20-2-1 TO 36A 2-4-22-2 Training Equipment Bench Items: Torque-Flite Automatic Transmission (2) C-4 Ford Vacuum Control Unit (2) Engine Dynamometer with Automatic Transmission (4) Mechanic's Handtools (1) Special Tools (4) Training Methods Performance (4.5 hrs) Outside Assignment (2 hrs)

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PLAN OF INSTRUCTION (Continued)

1 UNITS OF INSTRUCTION AND CRITERION OBJECTIVES	2 DURATION (HOURS)	3 SUPPORT MATERIALS AND GUIDANCE
		Instructional Environment/Design Laboratory (4.5 hrs) Instructional Guidance Following all safety precautions and following the procedures in TOs, perform adjustments and maintenance of automatic transmission. Stress energy and material conservation.
Related Training (identified in course chart).	2 Day 45	
10. Measurement Test and Test Critique	1.5	

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4-11 /18

LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE TWSTI 26 Feb 75 Easm	INSTRUCTOR
COURSE NUMBER 3ABR[redacted]0 47232	COURSE TITLE General Purpose Vehicle [redacted] Mechanic, Part 1
BLOCK NUMBER IV	BLOCK TITLE Tune-up and Troubleshooting

LESSON TITLE Scientific Tune-up of Mechanical, Battery, Ignition, Fuel, Lubrication, Cooling and Crankcase Ventilation Systems

LESSON DURATION

CLASSROOM/Laboratory D&D 5 hrs / Perf 7 hrs	LABORATORY/Complementary 4 hrs	TOTAL 16 hrs

POI REFERENCE

PAGE NUMBER 22	PAGE DATE 2 January 1975	PARAGRAPH 2

STS/CTS REFERENCE

NUMBER STS 473X0	DATE 3 Sep 1974

SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
1. Trainer: 61-2785 2. " 60-2761 3. " 60-2759 4. " 61-2781 5 " 61-2800 6. Mechanic's Common Hand tools 7. Special tools	None	None	1. 3ABR47330-WB-402 2. 3ABR47330-SG-402 3. 3ABR47330-SG-402A 4. T036A2-4-4-2 5. T033D6-3-4-1 6. Dynamometer Operator training handbook

(over)

CRITERION OBJECTIVES AND TEACHING STEPS

a. Provided engine trainer, tools, equipment, engine analyzer, TOs, workbook, following all safety precautions, use visual, auditory, operational means, and test equipment, to check starting, ignition, mechanical, and fuel-air systems IAW TOs and workbook.

TEACHING STEPS ARE LISTED IN PART II.

ATC FORM AUG 72 770

☆ GPO: 1972 779-364/28

EQUIPMENT LOCATED IN LABORATORY

8. Gauges
9. Engine Analyzer
10. Distributor advance tester

GRAPHIC AIDS AND UNCLASSIFIED MATERIAL

7. TO33D6-3-1
8. TO36A2-2-13-2
9. TO36A2-3-12-2
10. TO36A2-4-22-2
11. TO36A2-5-6-2

INTRODUCTION

1. Attention and Motivation: Gain the students' attention by making a starting statement, telling a story, or asking a rhetorical question. Then state that a large majority of the maintenance and repair work done on a vehicle is related to tune-up.

2. Review: Relate this lesson to previous lessons in the course, and ask the students for some of their experiences with these systems. Review and grade outside assignment. Reteach as needed.

3. Overview: This lesson will be a discussion of Tune Up and maintenance battery and starter system, ignition system, mechanical system, fuel-air system, anti-pollution and emission control systems. We will spend some time in the classroom discussing the procedures but much time will be spent in the lab actually tuning an engine.

BODY

11 Hrs 20 Min

PRESENTATION:

1. Ref: Para a, Part 1	3ABR47330-WB-402
a. Battery	3ABR47330-SG-402
(1) Visual Inspection	
(a) Cracks (b) Loose or corroded connections (c) Hold down device	Note: Stress that two reference manuals must be used - One for operating the equipment and one for the vehicle engine specs.
(2) Cleaning and servicing	
(a) Remove dried acid and oil film to prevent self-discharge	TO 33D6-3-4-1 p. 11
(b) Soda and water solution (c) Service with distilled water	Stress clean work habits in post maintenance clean-ups and professionalism when performing maintenance tasks
(3) Battery testing	
(a) State of charge	TO 33D6-3-4-1 p. 12
1 Use battery hydrometer	
2 Specific gravity should be 1.225 to 1.280at 80° F.	

3 Readings that vary over .025 from cell to cell indicate defective cells

4 Must compensate for electrolyte temp.

a for every 10° above 80° add .004 to float reading

b every 10° below 80° minus .004 from float reading

(b) Battery Capacity (Load) Test (High rate discharge) — TO 33D6-3-4-1 p. 13

1 Indicates internal condition

2 Battery voltage under load:

a 12 volt battery - not lower than 9.0

b 6 volt battery - not lower than 4.8

(c) Leakage Test - — TO 33D6-3-4-1

1 Performed to check battery self-discharge

2 If a voltage reading is obtained the battery should be cleaned with baking soda and water.

b. Starter Motor Tests

(1) Amperage draw test - performed when starter operation is unsatisfactory. — Also during routine tune-up

(a) Refer to mfg. manual for procedures — TO 33D6-3-4-1 p. 19

(b) Test results and indications

1 On Vehicle, high amp draw - Tight engine,

defective starter - perform bench test

2 On Vehicle Low amp draw - excessive resistance - perform circuit resistance tests. Brushes

3 OFF Vehicle normal draw, on vehicle high - engine

4 OFF Vehicle high draw - shorted field, dragging armature. Disassemble.

(2) Circuit Resistance Test

(a) Connect voltmeter in parallel with circuit and operate circuit while observing voltmeter

(b) General Specifications

1 Insulated Circuit Max .5v

2 Ground Circuit Max .2v

(c) Isolate resistance by tracing circuit back to battery.

(d) Sources of excessive circuit resistance

1 Loose or corroded battery connections

2 Poor brush contact

3 Poor internal Connections

2. Ref: Para a, Part 1

a. Ignition Systems (Conventional) CHECKS

(1) Wiring: inspect for frayed, cracked, broken insulation, connections

(3)

(2) Oscilloscope Test - perform IAW Mfg. Manual. Used to "see" the general condition of the ignition system

(3) Ballast Resistor - Voltage

(4) Primary Circuit Voltage Drop Tests

(5) Coil Tests

  (a) Leakage

  (b) Continuity

  (c) Capacity

(6) Distributor

  (a) Points

    1 Alignment — Dyno Book p. 6-9

    2 Spring Tension - weak; high speed miss

    3 Gap and/or dwell

    4 Dwell Variation - over 2° with

      a change in dist. speed - worn bushings

      b change in throttle opening - breaker plate bushings worn — 5 normal on some dist.

    5 Circuit Resistance - Distributor Primary Connections, point contacts

    6 Burned Blue-high primary voltage

    7 Burned Black - Oil vapors or lubricant

    8 Pitted - bad condensor - — Dyno Book p. 6-10

  (b) Cam Lobe accuracy - Dist. Tester or Scope test

...

- (c) Condenser
  - 1 Resistance
  - 2 Capacity
  - 3 Insulation
- (d) Advance - Mechanisms - with Dist. Tester or on engine
  - 1 Centrifugal - Improper advance, check spring tension and weight movement.
  - 2 Vacuum - Too little - check diaphragm for hole or movement of breaker plate

(7) Secondary wiring

- (a) Oscilloscope Test - high resistance wire(s) - high firing line(s)
- (b) Ohmmeter Test 5000 ohms per foot of wire, maximum, not to exceed 15,000 ohms.

(8) Distributor Cap & Rotor

- (a) Oscilloscope Test
- (b) Carbon Tracks
- (c) Terminal Corrosion
- (d) Cracks

(9) Spark Plugs

- (a) Oscilloscope Test - action of the plug firing can be seen in the firing section.
- (b) Inspection
  - 1 Black, Dry fluffy carbon - Rich AFR, cold plug.

2 Black, moist carbon - oil fouled

3 Light tan or gray - normal

4 Blistered - too hot

(c) Service

1 Clean in solvent

2 Sand blast

3 File electrodes flat

4 Regap with wire gauge

5 Test under pressure

6 Replace gasket when reusing old plugs.

(10) Ignition Timing

TO 33D6-3-4-1 UDT
TO 33D6-3-16-1
Dist. Advance Tester

(a) Adjust idle to mfg. specs.

(b) Check Mfg. manual for procedures, specs, and timing marks

(c) Remove vacuum lines and plug if required

(d) Timing marks should align when shining a timing light

b. Ignition System (Conventional) TUNE-UP

(1) Distributor

(a) Points Replacing

1 Lubricate cam lobe

2 Install points, check alignment & spring tension

3 Adjust gap recheck with dwell meter

4 Visually inspect wiring and connections

(b) Condenser - replace when required

(c) Secondary wiring - replace when required

(d) Distributor cap & rotor - replace when required.

(e) Spark plugs - Replace when required, First check gap. Keep electrodes clean.

(f) Ignition Timing

1. Check Dwell
2. Adjust Idle speed
3. Check Mfg. manual for Procedures, specs, and timing marks.
4. Remove and plug vacuum lines as required
5. Rotate distributor body to align timing marks
6. Re-check marks after tightening distributor hold-down

APPLICATION:

1. Ref: Para a, Part 1

TRAINERS

61-2785 Engine Ford V-8
60-2761 Engine GMC 6 cyl.
60-2759 Engine IHC 6 cyl.
61-2781 Engine Chevy 6 cyl.
61-2800 Engine Valiant 6 cyl.

TO 33D6-3-16-1
TO 33D6-3-4-1
TO 36A2-2-1-122
TO 36A2-3-12-2
TO 36A2-4-22-2
TO 36A2-5-6-2
TO 36A2-4-4-2
Special Tools
Gauges, Hand Tools
Engine Analyzer

Allow students to replace all defective parts on engines.

END OF DAY SUMMARY

SUMMARY: The purpose of today's lesson was for you to have an understanding and be able to inspect, test, and determine the condition of the battery, starter and ignition systems, then make the repairs necessary to return these systems to a serviceable condition.
The main points to remember:
The Battery must be in satisfactory condition before the starting and ignition systems can be properly tested and malfunctions corrected.
The starting system must operate without malfunctions also.
Finally, the ignition system must be correctly identified, diagnosed, and serviced to eliminate as much as possible, future malfunctions.

Use Oral Questions or daily appraisals at this time to determine areas to be retaught.

1. Q. What does the specific gravity test determine?
   A. State of charge.

2. Q. What does the capacity test indicate?
   A. Internal condition.

3. Q. How do you determine whether high amperage draw is caused by a tight engine or defective starter?
   A. Perform a bench test on the starter.

4. Q. What causes excessive voltage drop?
   A. Excessive Resistance.

5. Q. What is the oscilloscope used for?
   A. To help analyze the ignition system by giving a picture of the firing of all cylinders.

6. Q. Name a common cause of excessive voltage drop in the distributor pramary circuit.
   A. Burnt points.

7. Q. What causes dwell variation above normal?
   A. Worn distributor bushings or breaker plate bushings.

8. Q. What could cause too little mechanical advance?
   A. Sticking weights.

9. Q. What does a high firing line on one cylinder show on the oscilloscope?
   A. High required voltage.

10. Q. What causes a spark plug to accumulate a deposit of dry, black, fluffy carbon?
    A. Rich AFR or Cold plug.

ASSIGNMENT CTT POI Para 2a, b   2 hrs.

The assignment for tomorrow will be to briefly look at Exercise 3, page 18, 19, 23 & 24 of WB 402. Also read pages 9-19 in TO 33D6-3-4-1. You must be able to make a compression test to determine the internal condition of an engine. This is what you will be doing in the lab tomorrow. Use the method of study we have discussed before. Namely: SQ3R - Survey, Question, Read, Recite, Review.

INTRODUCTION TO NEW DAY'S WORK

1. The mechanical system of the engine is a necessary part of the overall engine. Without it we would not have an operational engine. And it must work in harmony with the rest of the engine systems.
    a. The mechanical system might be compared with the workings of a fine watch. As each tick of the watch means every mechanical part must be in exactly the right place to give the correct time; so must the mechanical parts be in exactly the right place at the right time for a vehicle's engine to perform as it was built to.
2. Yesterday we applied our knowledge of the electrical, starting, and battery systems, and how to tune-up those systems.
3. Today we will study mechanical and fuel/air systems. We will perform tests, and measure compression and valve mechanisms, and measure and adjust fuel/air systems, malfunctions and corrective action. We will also cover the engine support systems.

PRESENTATION:

1. Ref: Para a, Part 1 — 3ABR47330-WB-402
   -SG-402
   -SG-402A
    a. Mechanical System
        (1) Compression testing
            (a) Normalize engine
            (b) Clean area remove plugs
            (c) Open choke and throttle plates
            (d) Insert gauge and crank engine at least 4 times
            (e) Record readings repeat for all cylinders - analyze later
        (2) Analyzing Compression Test Readings
            (a) One low cylinder
                1 Burned Valve - Popping at exhaust or carb

- 2 Broken ring - Blow by
- 3 Ring gaps lined up. Blow by
- 4 Blown Head gasket
  - a To outside - hissing noise
  - b To water jacket - bubbles in coolant, use radiator pressure tests
- 5 Hole in Piston - Blow by

(b) All low cylinders is generally wear - Blow by

(c) Two low cylinders (adjacent) usually blown head gasket

(3) Wet compression test will show whether low readings are caused by worn rings on defective valves.

(4) High compression - Carbon build up in combustion chamber

(5) Cylinder Leakage Test

- (a) perform IAW tester Mfg. Instr.
- (b) Readings should be comparatively even and less that 20%.
- (c) Listen in carb, exhaust pipe - valves
- (d) High leakage in adjacent cylinders - head gasket
- (e) Bubbles in radiator - leak to cooling system
- (f) Hissing out oil filler cap - leak into crankcase

(6) Valve Adjustment

Only perform when engine will not start and idle

(a) Cold adjustment using valve overlap method

1 To place any cylinder on T.D.C. compression, place its companion cylinder in the overlap position

2 Prefer adjusting in the sequence of firing order

3 Always hold adjuster while tightening lock nut

(b) Hot Valve Adjustment

1 Engine must be normalized and idle slow as possible

2 Mechanical Valve Lifters Use go-no-go method; proper gauge will go, .004 oversize No. Go

3 Hydraulic Lifters - zero lash (Mfg. specs)

4 Valves adjusted too loose; noisy operation, and worn valve stems

5 Valves adjusted too tight; loss of power and burned valves.

(7) Vacuum Tests - perform IAW Tester mfg. Instructions to aid in determining mechanical condition of the engine

b. Support Systems

(1) Lubrication

(a) Oil level and condition

1 Dirty oil-Change

        2 Milky colored oil - water

        3 Clear bubbles in oil - Fuel

        4 Foamy - Wrong grade or overfilled

    (b) Leaks - Tighten or replace gasket

    (c) Filter

    (d) Pressure, hook manual gauge to output side of pump

    (e) Low oil pressure - worn engine bearings, bad oil pump, pressure relief valve stuck open.

    (f) High oil pressure, Pressure relief valve stuck closed

(2) Cooling System

    (a) For overheating or boiling condition, check:

        1 Coolant level and condition

        2 Fan belt

        3 Leaks and clamps, check hot and under pressure - use pressure tester.

        4 Pressure cap, raises boiling point of coolant

        5 Anti-freeze content of coolant — Dyno book. p. 5-22

        6 Manifold heat control valve

    (b) Slow warm up - check thermostat

    (c) Vacuum Valve prevents vacuum build up in radiator when coolant contracts.

(3) Positive Crankcase Ventilating

    (a) Removes blowby vapors from the crankcase

(b) Prevents condensation & sludge formation

(c) Open and Clsed types

(d) P.C.V. Valve controls vapors into intake manifold

(e) Test Valve IAW Mfg. specs

(f) Replace valve when recommended

2. Ref: Para a, Part 1

a. Fuel System

(1) Fuel Pump

(a) Volume test - perform if high - speed performance is poor and lack of fuel at carb. Best overall test

(b) Pressure test - important for high speed. Tests spring pressure

(c) Vacuum test - perform if volume or pressure is low - Tests diaphragm

(2) Carburetor

(a) Float level - very important to performance and fuel economy

Check only if rich AFR at idle.

(b) Choke operation

(c) Idle A/F mixture - only IAW with Mfg. specs.

(3) Evaporative Control System

(a) Control fuel vapors from tank

(b) Carbon Canister

(c) Vacuum Lines

APPLICATION:

1. Ref: Para a, Part 1.

TRAINERS:
60-2761 Engine GM 6 cyl.
60-2759 Engine IHC 6 cyl.
61-2781 Engine Chevy 6 cyl.
61-2800 Engine Valiant 6 cyl.
61-2785 Engine Ford V-8

TO 36A2-4-4-2
TO 33D6-34-1
TO 33D6-3-16-1
TO 36A2-2-1-122
TO 36A2-3-12-2
TO 36A2-4-22-2
TO 36A2-56-2
Gauges, Hand Tools,
Special Hand Tools,
Engine Analyzers,
Distributor advance
Tester

Allow students to replace all defective parts on engines.

EVALUATION:

1. The quizzes for the two days will be given and reviewed for any weak areas. These quizzes will be in addition to daily quizzes and questions as the need arises.

CONCLUSION Hrs Min

SUMMARY AND REMOTIVATION:

1. Briefly cover the material of the last two days, emphasizing the main points that are as follows:

   a. The electrical system consists of many sub-assemblies that are tied in to each other. If one does not function properly, it will affect the rest of the electrical system, as well as the other engine systems, example: if the battery is not fully charged, an accurate compression test cannot be made. And I am certain that you could think of many more examples if time permitted.

   b. The fuel/air system is a member of the triangle and its function is to deliver fuel and air in the exact quantities to the combustion chamber.

   c. The mechanical system is also needed to help make the engine run and compression within manufacturer's specifications is imperative for an efficient operating engine.

d. There are also support systems that are just as important as any of the aforementioned systems. These are as follows:

(1) The lubrication system is used to reduce friction and the accompanying wear to the moving engine parts and accessories.

(2) The cooling system is also a very important support system. Without it, the mechanical system could not function very long. It takes the heat away from the combustion chamber, as well as the other moving parts of the engine. Remember that the temperature under the hood outside of the engine sometimes reaches 300-400 degrees F. so a hard working cooling system is a necessity.

2. You now have used scientific methods of engine tune-up. Now you should be able to apply your abilities for the USAF as well as for personal gain. The sooner you are able to demonstrate to your immediate superiors how well you perform your assigned duties, the sooner you will receive monetary increases through promotions. This applies whether you stay in the Air Force or return to civilian life. No one can take away your knowledge! It has been freely given, so do not be afraid to pass it on to someone less fortunate than you, someone not attending a formal technical school.

USE ORAL QUESTIONS TO DETERMINE WEAK AREAS.

1. Q. What will you see at the oil filler cap if the rings are excessively worn? Open System?

A. Blowby.

2. Q. Burned valves can be detected by listening in which area(s) while the engine is running?

A. Tail pipe & carburetor.

3. Q. What will result when valves are left adjusted too tightly?

A. Loss of power, burned valves.

4. Q. Where do you connect a gauge to check oil pressure?

A. Main oil gallery.

5. Q. What would you check if the engine took too long to warm up?

A. Thermostat.

6. Q. What would you check if the crankcase was developing excessive pressure and sludge?

A. PCV system.

ASSIGNMENT AND CLOSURE:

1. The next lesson will cover tune-up and troubleshooting all systems of

the entire engine, using Diagnostic Test Equipment such as: The chassis dynamometer and Simpson Engine Analyzer. Therefore your assignment is as follows:

CTT POI Para 3a, b, c, d.

a. Read and study PT 403, and WB-403. Be prepared to answer questions concerning the components and operation of the chassis dynamometer and the Simpson Engine Analyzer, its components and operation. Also study Chapters 4-5-6, and the chart on the back page of Dynamometer Operator Training Handbook. DO NOT MAKE ANY MARKS IN THESE BOOKS! I REPEAT--DO NOT MAKE ANY MARKS IN THESE BOOKS! Answer the questions at the end of each chapter on a separate sheet of paper and turn it in tomorrow. Please put your name, class number and tomorrow's date at the top of the first page. Read pages 64, 65 & 79-94 of TO 33D6-3-4-1.

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LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE TWSTI 24 Feb 75	INSTRUCTOR
COURSE NUMBER 3ABR[redacted] 47232	COURSE TITLE General Purpose Vehicle R[redacted]n, Part 1 Mechanic
BLOCK NUMBER IV	BLOCK TITLE Tune-up and Troubleshooting

LESSON TITLE Tune-up and Troubleshooting Engine Mechanical, Fuel, Ignition, Anti-Pollution, and Emission Control Systems Using Diagnostic Test Equip.

LESSON DURATION

CLASSROOM /Laboratory	LABORATORY/Complementary	TOTAL
D&D 6.5 Hr/Perf 11.5 hrs	6 hrs	24 hrs

POI REFERENCE

PAGE NUMBER	PAGE DATE	PARAGRAPH
23	2 January 1975	3

STS/CTS REFERENCE

NUMBER	DATE
CTS 473X0	3 Sep 1974

SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
1. Trainer: 60-2761 2. " 60-2759 3. " 61-2781 4. " 61-2800 5. " 61-2785 6. Various Vehicles 7. Mechanic's Common Hand tools (over)	None	None	1. 3ABR47330-PT-403 2. 3ABR47330-WB-403 3. TO 33D6-3-10-1 4. TO 33D6-3-14-1 5. TO 33D6-3- 6-1 6. TO 36A2-4-20-2 7. TO 36A2-2-13-2 8. TO 36A2-3-8-2 (over)

CRITERION OBJECTIVES AND TEACHING STEPS

a. Given tools, vehicle, chassis dynamometer, TOs, and practicing automotive personnel and equipment shop safety, use visual, auditory, operational means, and test equipment to check mechanical, ignition, and fuel-air systems IAW TO.

b. Given tools, engine trainer, engine analyzer, TOs, and practicing all safety precautions, use visual, auditory, operational means, and test equipment to check mechanical, ignition, and fuel-air systems IAW TO.

c. Given work book, and engine trainers, determine procedures for inspection, maintenance, and repair of anti-pollution and emmission control systems follow procedures outlined in workbook.

TEACHING STEPS ARE LISTED IN PART II

EQUIPMENT LOCATED IN LABORATORY

8. Universal Engine Analyzer (Simpson)
9. Vehicle Chassis Dynamometer
10. DISTRIBUTOR ADVANCE TESTER

GRAPHIC AIDS AND UNCLASSIFIED MATERIAL

9. TO 36A[illegible]-2-22
10. Chart: CAFB74-43
11. Chart: CAFB63-15
12. Chart: CAFB63-12
13. Chart: CAFB63-13
14. Dynamometer Operator Training Handbook
15. Slide, Vehicle Emission Control
16. TO36A2-3-12-2
17. TO36A2-3-14-1
18. TO36A2-4-17-2
19. TO36A2-4-22-2
20. TO36A2-5-6-2

INTRODUCTION 20 Min

1. Attention and Motivation: Use a statement concerning the legal obligation the mechanic has to the public in the proper service of emission control systems. Read the last paragraph on page 24 of SG 402. Not only does the mechanic have a legal obligation to service emission controls according to Mfg. instructions but all motorists have an obligation to keep their cars running clean lest they infringe on others rights to breathe.

2. Review: So far in this block we have learned how to troubleshoot the electrical fuel and mechanical system without test equipment then we used test equipment to fine-tune the engine. Review & grade outside assignment. Reteach as needed.

3. Overview: Before one begins to tune a modern engine he must understand how this will affect the operation of the engine. He should realize that any time he makes an adjustment on the ignition or carburetor system he is going to affect the output of polluting gasses from that engine. We are going to learn today what is meant by automobile pollution, how the pollution control systems work and how performing a tune-up correctly will ensure that the pollution output from an engine is kept within allowable limits.

BODY 17 Hrs 20 Min

1. Ref. Para c, Part 1

   a. Discuss the purpose of engine emission devices and the importance of proper inspection, maintenance and repair procedures.

   Use SG 402 & 402A
   Show Emission Control Slides

      (1) Smog - define

      (2) Types of Smog

         (a) London - Industry
         (b) LA - Automobile

      (3) Pollutants expelled from the automobile (40-60% of all pollution)

      Contained in exhaust

         (a) Carbon Monoxide 93% of all pollution CO.

            1 Result of combustion with too little air

            2 Reduces body's ability to carry oxygen in blood

3 Increased when combustion chamber gets cooler	
4 Reduced by leaner AFR (more air) and longer burning time (timing)	Emphasize importance of tune-ups.
5 Engine Modification	
(b) Hydrocarbons 63% of all pollution HC	
1 Harmful when trapped under "inversion layer" and reacted on up in by the sun: "Photo chemical smog." Aided by moist air or high humidity "LA type" smog.	"Quench area" Fig. 5 inversion layer - cold air held under warm air. Ozone is also photo-chemical smog.
2 Unburned gasoline	
3 Exhaust Hydrocarbons. Result from incomplete combustion in engine 55% of hydro carbons	
a Ingition miss b Compression loss c Low operating temp.	Emphasize importance of tune-ups. Unturned engine increases hydro-carbon 5X or more.
4 25% of hydrocarbons are emitted from crankcase blowby.	Fig 6 SG 402
5 20% of hydrocarbons are emitted from fuel (tank & carb.)	
(c) Nitrogen oxide - 50% of all pollution NOx	When CO and HC go down, NOx goes up & vice versa
1 Increase as engine temp. increases	
2 Combines with HC to produce Photochemical Smog	
3 Controlled by modified engine and ignition	Retarded Timing

(d) Particulates 9% of all pollution

  1 Lead is considered possibly dangerous to human life

  2 Lead coats the internal parts of any system that catalytically reduces exhaust pollution.

(e) Sulphur Dioxide - very small amount, 5% of total emitted. Mixes with moisture to produce sulphuric acid. Damaging to plants, humans & property.

(f) Asbestos fibers in brake linings and clutch discs. Not proven but under study.

b. Discuss the operation of Vehicle Emission Control Devices

(1) Positive Crankcase Ventilation

Fig. 8 SG 402 closed system

(a) Purpose - To remove crankcase blowby vapors from the engine thereby preventing condensation to form sludge, and route the vapors to the intake manifold and engine to be burned thereby preventing hydrocarbon contamination of the atmosphere.

(b) Operation -

  1 Fresh air is drawn into air cleanter and routed to valve cover.

  2 Fresh air mixes with crankcase vapor and leaves by the hose connected between the rocker arm cover and intake manifold.

  3 PCV valve controls flow of vapors from crankcase to intake manifold.

4 High manifold vacuum (at idle) draws the valve to the manifold end of the housing restricting flow of crankcase vapors.

5 When vacuum is decreased as the throttle is opened the spring overcomes vacuum and mover the valve toward the crankcase end of the housing, allowing more vapors to flow.

6 If the valve is stuck open excessive vapors will be allowed to enter the intake manifold at idle causing poor idle. No effectton high speed operation.

7 If the valve is stuck closed or plugged there will be a lack of crankcase ventilation causing excessive crankcase pressure and oil contamination.

(c) Testing

1 Test in accordance with manufacturer's instructions

2 Use commercially sold PCV system tester.

3 Alternate test - Plug PCV hose. A reduction in engine RPM should occur.

(d) Servicing

1 Clear valve and filters or replace as required by manufacturer

2 Inspect, clean and replace if required hoses, tubes, and fittings.

(2) EXHAUST EMISSION CONTROL

(a) Air Injection — "Smog Pump"

1. Purpose - directs a stream of fresh air into the exhaust manifold. This stimulates further burning of (hydrogen) thus reducing HC and CO.

2. Components

   a. Air Pump - belt driven

   b. Air manifold for each head

   c. Check valve

   d. Diverter Valve - "Gulp,""by pass" or "Dump" valve

   e. Connecting hoses.

3. Operation

   a. The pump delivers compressed air through the air manifold to the exhaust manifold where it mixes with the exhaust.

   b. This mixture ignites and burns here rather than passing out the exhaust pipe.

   c. The check valve prevents exhaust gasses from entering the pump.

   d. The diverter valve is connected to intake manifold vacuum and controls the direction of air flow from the pump. During decelleration the valve prevents fresh air from entering the exhaust manifold, thus preventing backfire.

4 Diagnosis -

a If backfiring occurs, check the diverter valve, leaking air manifold, ignition timing, or air/fuel ratio

b If emissions are above standards check engine tune-up before the AIR system. Then perform detailed check of entire AIR system IAW Mfg. recommendations.

5 Names used by Manufacturers

a GM - AIR - Air Injector Reactor

b Ford - Thermactor

c Am. Mtrs. - Air Guard

d Chrysler - limited use until 1975

(b) Engine Modification (Combustion Control)

1 Ignition Timing

a Generally more retarded at idle and stays retarded until higher speeds.

- Wider throttle Fig. 29 SG 402

b Commonly used controls

(1) Thermostatic Vacuum Switch (GM) - Advances timing at idle when engine becomes hot from retarded timing. Located in engine coolant jacket near near front of engine.

(2) Vacuum advance Valve - provides vacuum to distributor during decelleration for more complete com-

(3) Transmission Controlled Spark - (GM) keeps timing retarded until transmission is placed in high gear (TRS FORD)	Reduces NOx (NOx Control System Chrys)
(4) Temperature Switch - allows timing to advance when engine is cold	All work together
(5) Vacuum advance solenoid - Valve which controls vacuum to the advance unit on the distributor and is controlled electrically by temperature and the transmission.	
(6) Speed Controlled Spark - (GM) A speed sensor controls a vacuum valve which prevents timing advance until approx. 35 mph. and retards timing on decelleration below approx. 25 mph. (ESC FORD)	
(7) Dual Controlled Vacuum Advance (GM FORD) Allows vacuum to retard timing at idle and advance timing above idle and during overheat conditions	
(8) Distributor Retard solenoid - Retards Timing during idle and decelleration. Solenoid on distributor is grounded when throttle contacts stop. (Chrys)	

(9) Distributor Advance Solenoid - (Chrys) Provides 7-8 degrees of spark advance during starting. Activated by starter relay.

(10) Mechanical Advance (All) occurs at higher speed

(11) Orifice Spark Advance Control - OSAC (Chrys) Delays vacuum to advance for 17 seconds when going from idle to part throttle above 60°F. For control of No_x

2 Distributors - electronic ignition is being used to prevent deteriorating breaker points and changing timing.

3 Carburetion

a Carburetors designed and calibrated to provide a leaner Air/Fuel ratio

b Idle mixture limiter caps

c Strict adjustment procedures

d Internal idle fuel limiting orifice

e Idle stop solenoid - prevents dieseling

(1) Energized when ignition switch turned "on" 69

(2) Idle speed adjusted by turning plunger in or out

(3) With ignition switch off, plunge contracts and throttle lever strikes throttle stop screw

(4) Perform two adjustments - one with solenoid energized, one with solenoid IAW Mfg. specs.

f Some throttle solenoids slow the closing of the throttle on decelleration preventing an excessively rich mixture.

g Carburetor Air Temperature Control - provides warm intake air to carburetor when under hood air temperature is lower than 100% to provide better vaporization and leaner mixtures.

(1) Usually vacuum operated

(2) Air valve should be closed when cold

(3) Warm air passing exhaust manifold enters the air cleaner to signal the temperature sensor to open the air door in the snorkel to under hood air.

4 Hotter thermostats are used to provide more complete combustion. In addition higher radiator pressure caps are used to prevent over boiling

5 Compression Ratios - Lowered to allow use of low lead fuel and more controlled combustion.

less heat during ignition reduces NO_x

6 Exhaust Gas Recirculation (EGR) - Meter small amounts of exhaust gas into the int-ke manifold which lowers combustion temperature, lower forma-of NO_x. Exhaust flow could be regulated by a fixed orifice or vacuum controlled valve. More vacuum is applied to valve when throttle is opened. Cold Temperature may delay opening of EGR valve through a temperature sensitive vacuum valve.

7 Catalytic Converter - A small stainless steel muffler that has a ceramic honeycomb - like core coated with platinum and palladium. These metals stimulate a chemical reaction that converts carbon monoxide, and hydrocarbons into harmless carbon dioxide and water vapor.

- a Must use unleaded gasoline

  Nozzle & tank

- b Sometimes used with air pump
- c Radiate excessive heat
- d Expensive

(3) Evaporative Emission Control

(a) Purpose - To prevent fuel vapors from entering the atmosphere from the fuel tank and carburetor

(b) Components

1 Sealed fuel tank vented to a vapor separator

2 Charcoal vapor storing canister

3 Non-vented filler cap

4 Overfill limiter tank

5 Sealed carburetor vents

6 Hoses - fuel resistant

(c) Operation

1 Vapors from the fuel tank collect in the vapor separator

2 Some vapors condense and the liquid fuel returns to the tank.

3 Remaining vapors are carried through a line to the carbon cannister in the engine compartment and stored

4 During engine operation the fuel vapors are drawn from the canister to the intake manifold and burned.

5 Non-vented filler cap releases only under pressure of ½-1" or vacuum of ½-1".

6 Overfill limiter tank - fills and empties slowly and allows room for fuel expansion after fill-up.

APPLICATION: Para c, Part 1

TRAINERS
61-2785-Engine Ford V-8
60-2761-Engine GMC 6 cyl.
60-2759-Engine IHC 6 cyl.
61-2781-Engine Chevy 6 cyl.
61-2800-Engine Valiant 6 cyl.
Mechanics common hand tools
Vehicles
TO's

36A2-3-8-2 '68 Ford
36A2-2-1-122 IHC
36A2-3-12-2 Ford 289 Eng.

TRAINERS
36A2-4-22-2 Chevy 250 Eng.
36A2-5-6-2 Chrysler slant 6
36A2-4-17-2 '67 Chevy Shop Manual

END OF DAY SUMMARY

SUMMARY:

1. We have discussed the three major pollutants expelled from the automobile- CO, HC, & NO_x. CO and NO_x are emitted from exhaust and HC is emitted from the crankcase, exhaust and fuel tank. All three are a danger to our health and environment. Exhaust emissions are controlled by air injection, revised timing and carburetion, hotter thermostats, lower compression, EGR, and the catalytic converter. Evaporative emissions are controlled by preventing the fuel system from venting into the atmosphere. Crankcase emissions are controlled by using the PCV system. Understanding how this is done and the effects of an improperly tuned engine will help us realize the importance of our job when we are performing a tune-up. Laws are in effect for those who cannot understand why we have emission control systems and must keep them maintained. Those concerned about the environment and the air they breathe need no laws.

USE ORAL QUESTIONS TO DETERMINE AREAS TO BE RETAUGHT

1. Q. Name the three major pollutant gasses.
   A. 1. Carbon Monoxide 2. Hydro carbons 3. Nitrous Oxides.

2. Q. Does the automobile produce "London type" of "A type" smog?
   A. "LA type."

3. Q. Briefly explain the operation of the air injection system.
   A. Fresh air is pumped into the exhaust system to combine with the hot exhaust gasses and produce a harmless emission from the tail pipe.

4. Q. Name some common engine modifications used to control emissions.
   A. Revised ignition timing & carburetor calibration, carburetor air temperature control, hotter converter. Lower compression ratios, EGR, Catalytic converter.

5. Q. Which prevents dieseling when the engine is turned off?
   A. Electrically controlled throttle solenoid.

ASSIGNMENT: CTT POI Para 3A 2 Hrs

1. The assignment for tomorrow is: Study PT 403 & WB 403 and Chapter 2 in the Dynamometer Operator Training Handbook and answer all questions at the end of the chapter on tablet paper.

INTRODUCTION TO NEW DAY'S WORK

1. Attention and Motivation: Using a startling statement, a rhetorical question, or personal experience, alert the students to the fact that this lesson will stand them in good stead someday--in the military shop, on their own automobile, or in a commercial establishment for monetary gain. Possibly it could help them to supplement their income during their stay in the Air Force.

2. Review: In the previous lesson, you have used certain types of scientific test equipment such as the Sun Universal Diagnostic Test Equipment, to analyze and correct engine malfunctions. You have seen that for every action of the engine, there was a reaction by the test equipment you were using at the time. Evaluate preparation for today's lesson.

3. Overview: In the following three days, you will become familiar with even more sensitive and intricate test equipment. The Chassis Dynamometer and the Simpson Engine Analyzer. These pieces of test equipment can be used together, or separately as required. As the name implies, the chassis dynamometer will not only analyze the engine, but the power train as well.

PRESENTATION:

1. Ref: Para a, Part 1	Stress SAFETY!
a. Dynamometer functions	3ABR47330-PT-403 Clayton Chassis Dyno Hand Book TO 33D6-3-10-1
(1) Designed to simulate all road conditions	
(a) Full throttle, low speed (heavy load)	
(b) Full throttle, high speed (partial load)	
(c) Rapid acceleration	
(d) Part throttle (light loads)	
(e) Coasting conditions	with flywheel engaged
(f) Power train testing	with windows closed
(2) Dynamometer components	List on chalkboard Chart: CAFB 74-43 Dynamometer schematic
(a) Rollers	
(1) Drive roller	

a Driven by rear wheels of vehicle being tested — TO 33D6-3-10-1

b Operates rotor in power absorption

(b) Idle rotor

1 Also driven by rear wheels of vehicle being tested

2 Drives tachometer generator by "O" ring type belt — Check "O" ring occasionally!

(3) Power absorption unit — NOTE: This unit must remain cool enough to touch at all times!
WARNING:

(a) Water filled

(b) Rotor has vanes which are forced through water

(c) Stator also has vanes, but they oppose water movement created by rotor

(d) Acts as water brake

1 More power required when more water is used

(4) Heat exchanger — Chart: CAFB 63-15 Water and Coolant Schematic

(a) Heated water from the power absorption unit passes thru a tube which is surrounded by cool water

(5) Solenoids

(a) Allow water to load or unload power absorption unit — Operate on 110V A.C. Controlled by Operator

(6) Torque bridge

(a) Variable resistor that is operated by the power absorption unit thru pressure on torque arm — Current is received from tachometer-generator transmitted to H.P. meter through torque bridge

- (b) Recieves signal from tacjometer generator and allows restricted current flow to power meter

(7) Tachometer generator

- (a) Provides electrical power to speed and power meter

(8) Flywheel

Chart: CAFB 63-12
Flywheel and Clutch Schematic

1. Flywheel can be disengaged at speeds under 30 M.P.H.
2. Do not engage flywheel while vehicle is in motion

b. Dynamometer cabinet

(1) Instrument panel

(a) Speed meter

Chart: CAFB 63-13
Power and Speed Meter

- 1 Indicates vehicle speed

(b) Power meter

- 1 Indicated road horsepower delivered to vehicle rear wheels

(c) Dwell meter

- 1 Indicates degrees of dwell of vehicle ignition points

(d) Exhaust gas analyzer

- 1 Gives vehicle air/fuel ratio

(e) Vacuum gauge

- 1 Indicates engine vacuum

(f) Tachometer

- 1 Indicates engine rpm

(g) Auxiliary vehicle cooler — Chart: CAFB 63-15 Water and Coolant Schematic

1 Contains motor, pump, heat exchanger and hoses

(2) Cools vehicle radiator by circulating water thru cooler

(3) Replaces normal air blast

APPLICATION:

1. Ref: Para a, Part 1 — Place on chalkboard a, b, c, d, e, f, g, h, i

   a. Faulty engine operation (compression)

      (1) Full throttle - low speed

   b. Compression testing with a dynamometer

      (1) Operate vehicle at full throttle low speed — 1200 R.P.M.

      (2) Short out each cylinder individually with screwdriver

      (3) Note drop in horsepower as each cylinder is shorted out — Max. H.P. drop - 2 hp

      (4) Compare horsepower drop

      (5) Least drop in horsepower indicates which cylinder(s) has poor compression

2. Ref: Para a, Part 1

   a. Electrical system (ignition)

      (1) Testing ignition system

         (a) High speed - open throttle miss indicates — 2500 R.P.M.

            1 Poor coil — Mention point float and point bounce

            2 Improper point gap

            3 Low primary voltage

            4 High resistance in the high tension wires

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         (b) Low speed - open throttle indicates — 1200 R.P.M. working hardest here

3. Ask pertinent questions about the various tests we made today and how this instrument makes road testing vehicles less difficult than actually taking them out on the highways.	3. Use oral questions to determine areas to be retaught

ASSIGNMENT

1. Tomorrow's lesson will be on the Simpson Engine Analyzer and its many uses, so the assignment will be for you to study WB-408. This is the work you will be accomplishing, and tells you how it will be done. Be especially watchful for the tests to be made, and the number of tests mentioned in this workbook.	1. Identify study materials.
2. Don't forget that you should try to study at the same time every evening, if possible. Also, eliminate as many surrounding distractions as you can. This may help you concentrate better.	2. Give reasons for student to study assignment.
3. This lesson will help you learn that there are many different types of test equipment, and you can adapt to any of them with just an understanding that they all have similar characteristics and will do the tasks required of them. Don't fear them. Don't abuse them. Just use them.	3. Mention method of study.

INTRODUCTION TO NEW DAY'S WORK

1. Arouse the students' interest by asking them to compare the Simpson Engine Analyzer with other types of test equipment they have used. Or use some other idea or example you may have that will stimulate discussion.

2. Yesterday we discovered that the dynamometer is an instrument that can be used for various tests that keeps us indoors away from traffic. It also can be used in any kind of weather. Therefore it can be said that it is a useful piece of equipment. Conduct oral quiz on operation and use of Simpson Analyzer.

3. Today we will discuss the many pieces of testing devices that comprise the Simpson Universal Engine Analyzer, and their uses.

   a. The purpose of the analyzer.

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1 Poor spark plugs

2 High tension cable shorted out

3 Cracked distributor cap

3. Ref: Para a, Part 1

a. Fuel System

(1) Proper carburetor operation is determined by connecting the exhaust gas analyzer to the tail pipe and the vacuum hose to the intake manifold

Test at all settings and at idle

(2) Air/fuel ratios should conform to specifications at all test points

APPLICATION:

1. Ref: Para a, Part 1

Vehicle Chassis Dynamometer
Distributor Advance Tester
TO 33D6-3-16-1
TO 36A2-3-14-2-1 '68 Ford

END OF DAY'S SUMMARY

SUMMARY

1. Today's lesson has shown you that there is much more to the dynamometer than just setting up the vehicle. The various test settings will tell you the condition of a given vehicle under road conditions.

1. Restate objectives of the lesson covered in this day.

2. The load settings that you tested the vehicle under were as follows:

2. Emphasize the area of major importance.

a. Full throttle and 1200 R.P.M.

b. Full throttle and 2500 R.P.M.

c. Rapid acceleration.

d. Part throttle and 2500 R.P.M.

e. Part throttle and 1200 R.P.M.

b. A brief description of it.

c. Performing various tasks with it.

PRESENTATION:

1. Ref: Para b, Part 1

ATTN: All Simpson electrical services are transistorized! Don't hook them up backwards

a. Purpose of the analyzer

(1) The universal engine analyzer is used to test, troubleshoot, and tune-up 4, 6 and 8 cylinder internal combustion engines with 6, 12, 24 or 32 volt electrical systems

61-2785 Eng., Ford V-8

b. Description of equipment

(1) The universal engine analyzer consists of 7 testing or analyzing components and 3 accessory or adapting components which are self-contained and independently operated. All components are mounted or contained within a portable cabinet

All of these components are described in TO 33D6-3-14-1

(2) The components and adaptors are as follows, with a brief description of each

(a) Adaptor set, 24 volt waterproof systems. Used for checking all types of sealed, watertight electrical systems

(b) Battery loader, test batteries under operating conditions

Do not multiply the A.H.R. with this battery loader!

(c) Analyzer, cylinder, determines the internal condition of the engine

(d) Tester, charging battery starter is used for troubleshooting the various systems as the name implies; namely, the charging, starting and battery systems

(e)	Analyzer, condenser magneto: is used to test and troubleshoot those systems	Same as item (j)
(f)	Tester, fuel pump, this unit is used to perform the pressure, volume and vacuum tests on the vehicle to determine the serviceability of the fuel and vacuum booster pumps	Vehicle should be running and hose placed in bottle to catch fuel
(g)	Connector set, spark plug, this set is used to connect the clips of the tachometer advance tester to the spark plug, in order to check spark timing and advance	Also used for secondary voltage tests & resistance
(h)	Tester, tach dwell ignition is used to troubleshoot the ignition system, and isolate the cause of the malfunction. It is also used to set the rpm and dwell when malfunction is corrected	
(i)	Tester, tachometer advance can be used to check and set ignition timing and check spark advance under various conditions	Use mfg specs as a reference
(j)	Analyzer, condensor magneto. This unit is used to conduct the various tests on the coil and the condenser in ignition systems	

APPLICATION:

1. Ref: Para b, Part 1

Various Vehicles
Special & Hand Tools
Universal Engine Analyzer
(Simpson)
Distributor Advance Tester
TO 33D6-3-16-1
TO 36A2-5-2-22
TO 36A2-3-14-2-1 '68 Ford

EVALUATION:

1. The quizzes for the three days will be given at this point. This will be in addition to the daily quizzes. Reteach where needed.

CONCLUSION 20 Min

SUMMARY AND REMOTIVATION:

1. Briefly cover the material of the last three days, emphasizing the main points that are as follows:

   a. The chassis dynamometer, its components and its versatility.

      (1) The console with its six meters and gages.

      (2) The rollers, tachometer/generator, power absorption unit and how it operates, the flywheel and air clutch that engages it.

      (3) How to prepare the vehicle and the chassis dynamometer.

      (4) The five test settings.

   b. The use and servicing of the Simpson Engine Analyzer.

      (1) How each component part of the analyzer is self-contained and multi-purposed.

      (2) Name them and give a brief description of each.

2. These instruments that you have been using these last three days are not as difficult as they may have seemed at first, and as you progressed, you discovered that they could be adapted to your own vehicle. You now have only a working knowledge of the Dynamometer and the Simpson equipment, but with time, patience, and practice, you can become very proficient with them.

ASSIGNMENT AND CLOSURE:

1. The final lesson in Block 4 will cover Lights, Warning, and Signal Systems. Therefore your assignemnt is to study the material in Workbooks 404, 404A, and 404B. This lesson will also cover headlight aiming and testing. This is also covered in the aforementioned workbooks.

2. An appraisal will be given on the assignment material. So be prepared on Monday.

LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE TWSTI 2676A 75	INSTRUCTOR
COURSE NUMBER 3ABR47330	COURSE TITLE General Purpose Vehicle Repairman, Part 1
BLOCK NUMBER 1V	BLOCK TITLE Tune-up and Troubleshooting

LESSON TITLE Troubleshoot, Diagnosis, and Repair of Vehicle Lighting, Warning, Signal Systems, and Headlight Testing

LESSON DURATION

CLASSROOM/Laboratory D&D 4.5 hrs/Perf 6 hrs	XXXXXXXX/Complementary 4 hrs	TOTAL 14.5 hrs

POI REFERENCE

PAGE NUMBER 24	PAGE DATE 2 January 1975	PARAGRAPH 4

STS/CTS REFERENCE

NUMBER STS 473X0	DATE 3 Sep 1974

SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
1. Vehicles 2. Mechanic's Common Hand tools 3. Special tools 4. Voltmeters 5. Ammeters 6. Continuity Lamps 7. Soldering Equipment (over)	NONE	NONE	1. 3ABR47330-WB-404 2. 3ABR47330-PT-404 3. 3ABR47330-WB-404A 4. 3ABR47330-WB-404B 5. 3ABR47330-PT-404B 6. Film: TVL-472A 7. Film: TVL-472B 8. T036A2-3-14-2-1 9. T036A2-4-17-2

CRITERION OBJECTIVES AND TEACHING STEPS

a. Without referrences, identify basic facts, relative to the function and operation of lighting, warning, and signal systems with 70% accuracy.

b. Provided with tools, equipment, testers, vehicle, and practicing all safety precautions, interpret circuits, schematics, and diagrams, and use visual, operational means, and test equipment to check electrical systems, following the procedures outlined in PT.

c. Given workbook, tools, equipment testers, and vehicle, and practicing automotive personnel and equipment shop safety, check and repair lighting, warning and signal systems, and check and adjust headlights following the procedures outlined in the workbook.

d. Given tools, test equipment, vehicle, and practicing all safety precautions repair or service vehicle safety accessories IAW manufacturer's specifications.

TEACHING STEPS ARE LISTED IN PART II.

EQUIPMENT LOCATED
IN LABORATORY

8. Terminal Kits
9. Battery hydrometers
10. AC type H headlight aimer
11. Weaver headlight tester-aimer

INTRODUCTION

0 Hrs 10 Min

1. Attention and Motivation: Create an atmosphere of leaning by an amusing story, students' previous experience, or your own experiences. At the same time, make the students aware of the importance of the lesson material and the everyday use they will make of it.

2. Review: Emphasize the importance of the previous lesson on testing sub systems and how they tie-in with today's lesson. Evaluate completion of assigned lesson in preparation for today's lesson.

3. Overview: Today's lesson will consist of discussion of troubleshooting and repair of the lighting, warning, and signal systems; also there will be films on headlight aiming and headlight testing after which there will be a demonstration on the use of AC and Weaver headlight testers, followed by practical application of the same.

BODY

8 Hrs 40 Min

PRESENTATION:

1. Ref: Para 1, Part 1.

   a. Functions and operation of lighting, warning and signal systems

   3ABR47330-PT-404
   PT-404B
   3ABR47330-WB-404
   WB-404A
   WB-404B

2. Ref: Para 2, Part 1.

   a. Lighting System

      (1) Headlights (all or individual) do not work

         (a) Loose battery cable, poor connections, defective switch, between headlight switch and dimmer switch and between dimmer switch and lights

         (b) Defective light switch

         (c) Burned out bulbs (if all bulbs are burned out check charging system for excessive output or check for high resistance caused by poor connections)

            1 Dimmer switch defective

            2 Poor grounds

(d) Headlight dim

- 1 Poor ground
- 2 Defective battery
- 3 Loose connections
- 4 Low output of charging system

(e) Tail lights don't work or are dim (similar conditions as headlights)

(f) Parking lights don't work or are dim (similar condition as headlight)

(g) Brake lights and switches

- 1 Defective switch, either pressure type in brake line, or mechanical type adjacent to attached brake pedal
- 2 Defective turn signal switch
- 3 Conditions similar to other lights just covered

(h) Signaling and warning

- 1 Turn signal lights
  - a Inoperative (all of individual)
    - (1) Fuse
    - (2) Loose connection or defective wiring
    - (3) Defective flasher
    - (4) Defective turn signal switch
    - (5) Burned out bulbs
    - (6) Poor grounds

- b Lights burn but do not flash or flash too rapidly
    - (1) Poor ground
    - (2) Defective or wrong type flasher
    - (3) Some flashers are designed to flash a designated size and number of bulbs, and others are designed to flash any number between 1 to 6
- c Cancels improperly
    - (1) Cam improperly positioned on hub of steering wheel
    - (2) Defective or improperly adjusted turn signal switch
- d Oil pressure and charging system indicator lights
    - (1) Lights won't burn when ignition switch is turned on
        - (a) Burned out bulbs
        - (b) Loose connections or broken wire from ingition switch or sending unit
        - (c) Defective sending unit (oil)

2 Light remains on when engine is running

- a Grounded wire from sending unit
- b Defective sending unit (oil)
- c No oil pressure
- d Defective voltage regulator (charging system)
- e Malfunctions in charging system

3 Horn

- a Horn(s) inoperative
  - (1) Loose connections or broken wire from horn button relay to horn, horn to horn
  - (2) Defective relay
  - (3) Defective horn button contacts
  - (4) Horn defective or out of adjustment
- b Horn operates continually
  - (1) Shorted wire
  - (2) Defective horn button contacts
  - (3) Defective relay

3. Ref: Para 3, Part 1.

- a. Fuel, temperature, oil gauges erratic or inoperative
  - (1) Loose connections or broken wires
  - (2) Defective sending unit

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- (3) Defective constant voltage regulator
- (4) Poor ground
- (5) To help isolate difficulties as being sending unit or gauge, disconnect wire at sending unit and ground it. If gauge registers, sending unit is defective; if gauge doesn't register, wiring or gauge is defective

4. Ref: Para 3, Part 1.

a. Windshield washers and wipers

- (1) Wiper inoperative
  - (a) Fuse
  - (b) Defective dash switch
  - (c) Wiper unit latching mechanism binding
  - (d) Defective relay control
  - (e) Defective wiper motor
- (2) Wiper motor will not shut off
  - (a) Wiper unit latching mechanism binding
  - (b) Relay control switch defective
- (3) Excessive speed in Hi
  - (a) Loose connection
  - (b) Resistor open
  - (c) Motor defective
- (4) Wiper operates in Hi or LO speed only
  - (a) Dash switch
  - (b) Grounded wire
  - (c) Open wire

b. Heaters & Defrosters

(1) Heater and defroster inoperative

(a) Fuse

(b) Dash switch

(c) Resistor

(d) Loose connections or broken wire

(2) Heater and defroster don't give off sufficient heat

(a) Water valve on block turned off

(b) Defective temperature control valve

(c) Broken control cable to temperature control valve

(d) Fresh air doors inoperative

(e) Inoperative or no engine thermostat

5. Ref: Para 4, Part 1.

Films: TVL-472 A&B
AC Headlight Aimer, Model H
Weaver Headlight Tester Model Wx45

a. Purpose of tester (Weaver) (AC)

(1) Test candlepower, beam direction of: Headlights, fog lights, and other adverse weather lights

(2) Also, furnish a positive means of correcting beam direction

b. Units

(1) Tester (Weaver)

(a) Photo-electric cell connected to a calibrated meter which measures light intensity in thousands of candlepower

   - (b) The calibrating stand is designed to hold a flashlight at a fixed height

- (2) Aimer (AC)
   - (a) Transit and target is designed to compensate for the floor slope
   - (b) Aimers and adapters, left and right, used to aim the headlight only

APPLICATION:

1. Ref: Para 2, 3 & 4, Part 1.	Weaver Headlight Aimer AC Type Headlight Aimers Various Vehicles Voltmeters, Ammeters, Continuity Lamps, Soldering Equipment, Terminal Kits and Hydrometers

END OF DAY SUMMARY

SUMMARY

1. You have been given a series of problems concerning lights, warning and signal systems, and quizzes covering the same. You have also tested lights, warning and signal systems on vehicles. In addition you have seen films on how to use the headlight tester and aimer to adjust headlights and discussed various difficulties encountered with mis-aimed headlights.	1. Restate objectives of the lesson (covered in this day).
2. You have also discussed and checked heaters, defrosters, windshield washers and wipers, and how the horns are adjusted for tone and volume.	2. Emphasize the area of major importance.
3. Pass out quizzes at this time and discuss any weak areas that show up.	3. Use oral questions to determine areas to be retaught.

ASSIGNMENT

1. Restudy Workbooks 404A and 404B, to prepare yourselves for the lab work the first thing in the morning.	1. Identify study materials.
2. This additional study will assist you in understanding the headlight tester and	2. Give reasons for student to study assignment.

the headlight aimer. You will be given a quiz on this material before we participate in the lab work.

3. Continue to set a time aside every evening for your studying, and don't forget-Please try to have as few distractions as possible! Then concentrate on the material only. Try the SQ3R method of study as suggested before. Please give it a fair try.

3. Mention method of study.

INTRODUCTION TO NEW DAY'S WORK

1. Today you will be able to put to use, the material discussed and tested yesterday. In your endeavor you may encounter difficulties with the vehicles and this is to be expected. These vehicles are purposely induced with various malfunctions for your benefit. Repair, replace, and adjust according to manufacturer's specifications. Conduct question/answer period to determine class preparation of assigned materials.

2. Remember the difference between the Headlight Tester (Weaver Model WX-45) and the Headlight Aimer (A.C. Model "H").

   a. The Weaver Headlight Tester measures the intensity of the headlight beam 1000 candlepower increments as well as locating the beam direction.

   b. The A.C. Headlight Aimer does not measure beam intensity, only direction.

3. You must be able to differentiate between the two types of aimers, their limitations as well as their capabilities. This you will accomplish today. We will now go to the lab area and conduct our experiments.

APPLICATION:

1. Ref: Para 3, Part 1.

2. Ref: Para 4, Part 1.

EVALUATION:

1. The quizzes for yesterday and today's activities will be given at this time. These quizzes are in addition to the daily quizzes and questions that are issued and interspersed throughout the lesson.

CONCLUSION 92 0 Hrs 10 Min

SUMMARY AND REMOTIVATION:

1. Briefly cover the material presented yesterday and today, and the experience

gained by applying their knowledge to the actual vehicles. Stress the importance of complying with the state laws governing the headlight settings, as well as Military and Commercial Specifications. Mention the other areas covered in this lesson, such as lights, warning, signal systems, heaters, defrosters, W/S washers and wipers, and gages.

ASSIGNMENT AND CLOSURE:

1. Review all the daily appraisals and notes pertaining to the block in preparation for final block measurement.
2. This completes the activities of Block Four and so the end of block tests will be administered at this time.
3. Study and respond to PT's 501, 501A & 501B dealing with Clutch Operation, Transmission Construction and Operation and Power Take-off Units.

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PREPARE THE MAN

WORKBOOK 3ABR47~~330~~232-WB-400

8-11

Technical Training

General Purpose Vehicle ~~Repairman~~ Mechanic

BLOCK IV
TUNEUP AND TROUBLESHOOTING

3 June 1970

CHANUTE TECHNICAL TRAINING CENTER (ATC)

This supersedes PT 3ABR47330-403 Through 404A, Student Workbook 3ABR47330-401A-II Through 404C-II, 25 April 1969.
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Vehicle Maintenance Branch
Chanute AFB, Illinois

3ABR47330-WS-401

FIELD METHODS OF TROUBLESHOOTING ENGINE SYSTEMS

OBJECTIVES

When you have completed the exercises in this worksheet you will be able to:

Use visual, auditory, and operational means to perform field methods of troubleshooting engine component malfunctions in the electrical system, fuel system, lubrication system, cooling system, and mechanical system.

Use operational and field methods to inspect, clean, test, service, and adjust the units that make up the vehicle components listed above.

Use handtools and publications properly and observe all safety precautions.

EQUIPMENT

Live Engine
Mechanics Tool Set

PROCEDURE

Using the worksheet as a guide for step-by-step procedures and important information, perform each task listed and read the information about it where applicable in the following exercises and as directed by the instructor.

Exercise 1

Locate and Correct Starting System Malfunctions Without Special Test Equipment.

1. Observe all applicable safety precautions.	1.
2. Obtain the necessary handtools.	2.
3. Obtain the applicable publication.	3. Reference used:
4. Attempt to start the designated engine and observe the cranking speed.	4. If when attempting to start engine it will not turn over, the following steps should be taken to isolate the trouble. Note: Make sure battery is in good condition and fully charged.

5.	Isolate the trouble developed in the starting motor circuit when starting motor fails to turn engine over or it turns slowly.	5.	If checking with the engine in the vehicle, the headlights or dome light is turned on while attempting to crank the engine. If using an engine trainer, use a continuity light hooked across the battery.
a.	Observe light(s) while attempting cranking, and isolate trouble if the light(s) stay bright and there is no cranking action.	a.	This condition indicates an open circuit at some point in the starting system (starting motor, switch, or control circuit).
(1)	Turn on ignition switch; close the control switch.	(1)	
(2)	Determine if the magnetic switch or solenoid operates.	(2)	Most magnetic switches or solenoids may be operated by hand. If starting motor operates when switch is closed, the trouble is in the control circuit.
(3)	Isolate malfunction in the control circuit.	(3)	Use jumper lead and connect around the control devices and switches. Note: If the trouble is in the starting motor, it must be removed and checked.
b.	Isolate trouble if light(s) goes out as the starter switch is closed.	b.	This condition indicates that there is a poor connection between the battery and starting motor. Note: Check at battery terminals.
c.	Isolate trouble if lights dim considerably as the starter switch is closed and the starting motor operates slowly or not at all.	c.	If battery is in good condition, there may be some mechanical condition in the engine or starting motor which causes the trouble.
6.	Have the instructor check the job.	6.	Instructor's initials ____________

Exercise 2

Locate and Correct Ignition System Malfunction Without Special Test Equipment.

Note: If engine cranks but fails to start, use the following procedures for checking out the ignition system.

1.	Check for spark at plugs.	1.	
a.	Remove spark plug wire.	a.	
b.	Turn ignition switch on.	b.	
c.	Crank engine with starter.	c.	

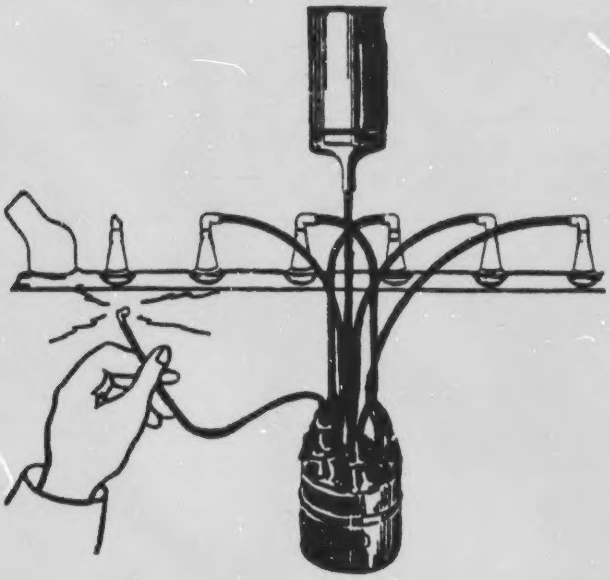

Figure 1. Checking Spark.

d.	Hold spark plug wire 1/4" from ground.	d.	If no spark occurs, the ignition is at fault, figure 1.
2.	Check for spark at coil.	2.	
a.	Remove coil wire from the distributor cap.	a.	
b.	Turn ignition switch on.	b.	
c.	Crank engine with starter.	c.	

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d. Hold coil wire 1/4" from ground.	d. If the spark jumps the gap, the trouble may be in the distributor cap or rotor. If no spark jumps the gap, the next place to check is at the points.
3. If a spark is noted from the high-tension coil wire, make the following checks:	3.
a. Distributor cap.	a.
(1) With all the wires in the cap, hold it upside down and open and close the points.	(1) If a spark jumps between the terminals of the cap, it should be replaced.

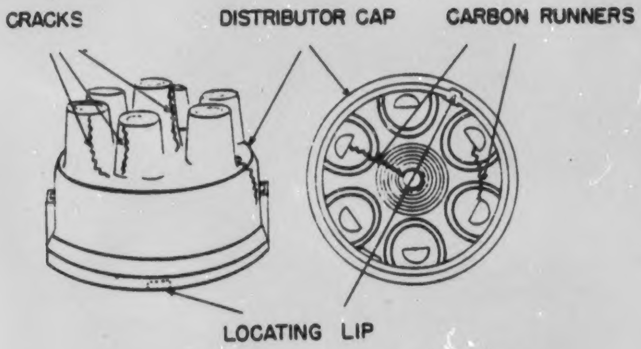

Figure 2. Cracked Distributor Cap.

(2) Remove every other spark plug wire from the cap and insert high-tension coil wire in one of these wells.	(2) If a spark jumps between terminal of the cap, it should be replaced. If no spark jumps between terminals, the remaining empty wire wells should be checked in the same manner. Jumping between terminals indicates a faulty cap, figure 2.
(3) Turn cap over and open and close points.	(3)
(4) Insert the high-tension coil wire in one of the spark plug wire wells and hold bottom edge of the cap 1/8" from ground.	(4)

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(5) Open and close points (switch on).	(5) If a spark jumps from the cap to ground, the cap is faulty, figure 2.
b. Rotor.	b.
(1) Visually check rotor tip.	(1) If the tip is burned or broken, it should be replaced.
(2) Test rotor by leaving on shaft and holding high-tension coil wire 1/4" from rotor tip.	(2)

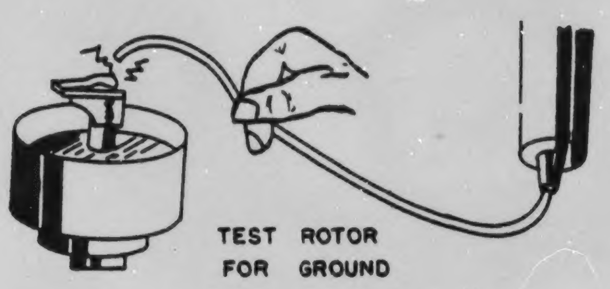

Figure 3. Testing for Grounded Rotor.

(3) Open and close points (switch on).	(3) A heavy spark jumping from wire to tip indicates a grounded rotor, figure 3.
c. Spark plug wires.	c.
(1) Insert each plug wire into coil high-tension lead and hold wire 1/4" from ground.	(1)
(2) Open and close points (switch on).	(2) If a good spark jumps to ground, the wires are good. No spark indicates a faulty wire.
4. If no spark was noted from the coil wire, paragraph 3, check the points.	4.
a. Open and close the points (switch on).	a. A slight arcing should occur each time the points are opened. If current is present at the points, but not at high-tension coil lead, the high-tension wire must be checked.

b. Remove high-tension coil wire and substitute spark plug wire in its place and hold plug wire 1/4 from ground.	b.
c. Open and close points (switch on).	c. If a spark jumps from the wire to ground, the original coil wire is broken. If no spark jumps, at least one spark plug wire should be tried. If there is still no spark, the coil secondary winding is faulty and the coil must be replaced.
5. Remove the primary wire from the distributor terminal and touch to ground.	
6. Using the test prod, follow the primary circuit back to the battery or until spark is found.	6. Caution: When checks are made make sure the coil to distributor wire is disconnected at the distributor terminal.
7. When spark is located, repair or replace any defective connections, wiring, or units, until spark is noted at the distributor end of the coil to distributor primary wire, arcing it to ground.	7.
8. If spark is noted when the coil to distributor primary wire is grounded, the following checks must be made:	8.
a. Open the points and touch the primary wire to the primary distributor terminal.	a. If a spark occurs, the distributor primary circuit is grounded.

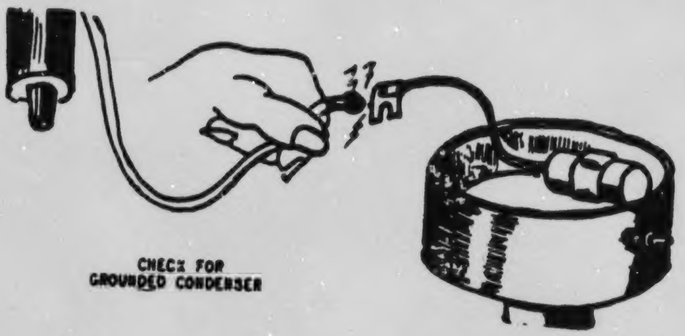

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Figure 4. Checking Grounded Condenser.

b.	Disconnect the condenser pigtail lead and touch the primary wire to the condenser pigtail lead, figure 4.	b.	If a spark occurs, the condenser is grounded. If no spark occurs remove the movable point.
c.	Touch the primary lead to the primary terminal.	c.	If a spark occurs, the primary terminal is grounded. If no spark is noted in either of the two preceding checks, the movable point is grounded and needs replacing.
d.	Open condenser test.	d.	

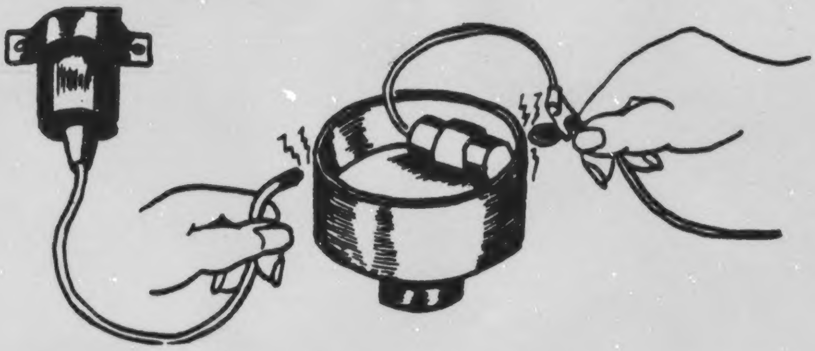

Figure 5. Checking Spark With Condenser in Circuit.

(1)	Hold the coil secondary wire close to ground and hold the primary wire and condenser pigtail together, figure 5.	(1)	
(2)	Touch the condenser pigtail and primary lead to ground and notice how far the spark jumps from the secondary wire.	(2)	

(3)	Strike the primary wire to ground and notice how far the spark jumps from the secondary wire, figure 6.	(3)	If there is no difference in the spark from the coil high-tension wire with the condenser in the circuit or out of the circuit, the condenser has an open. If no spark was present from the coil high-tension wire in the above checks, the coil secondary winding is at fault.
9.	Attach condenser pigtail and coil to distributor primary wire to the distributor terminal.	9.	
10.	Open and close ignition points manually with the ignition switch on, holding the high-tension coil wire 1/4" from ground.	10.	If there is a spark, the primary circuit, coil and coil high-tension wire are satisfactory.
11.	Turn the ignition switch on, hold the coil wire 1/4" from the ground, crank the engine and check for spark.	11.	If there is no spark in this test, the ignition points are either out-of-adjustment or the points are not making contact and need to be cleaned, adjusted, or replaced.
12.	Repeat check in paragraph 10 to make sure the points have been properly adjusted, cleaned or installed.	12.	
13.	Replace distributor rotor, cap, and wires.	13.	
14.	Check spark plugs.	14.	
a.	Make visual inspection.	a.	
b.	Clean with knife or sandblast if carboned up.	b.	Before gapping plug, be sure electrodes are filed flat.
c.	Adjust plug gap.	c.	Reference should be made to applicable technical publication. Gap setting should be _________ .
d.	Replace spark plugs.	d.	

e. With engine running at idle speed, use a screwdriver to determine if all plugs are firing.	e.
f. Recheck your work.	f. With the exception of ignition timing, the engine should now be ready to run. You have now completed checking the battery ignition system without using testing equipment.
15. Have the instructor check the job.	15. Instructor's initials: ___________

Exercise 3

Locate and Correct Mechanical System Troubles Without Special Test Equipment.

1. Observe all safety precautions to be applied.	1.
2. Locate the trouble indicated by excessive blowby during acceleration.	2. This trouble could be caused by scored cylinders and/or burned piston, or worn or broken rings.
3. Check valve condition.	3.
a. Check intake valves by removing air cleaner and observe sound at the air horn when accelerating the engine.	a. Defective intake valves will cause a popping at the carburetor air horn during acceleration.
b. Check the condition of exhaust valves.	b. Defective exhaust valves will be indicated by a "popping" or "sucking back" at the tailpipe.
Note: Make sure the idle speed and mixture is properly adjusted, and the spark plugs are firing properly. Hold a rag or piece of paper over tailpipe.	Note: This check cannot be made on engine trainers because of exhaust systems.
4. Check condition of headgasket.	4. A blown headgasket will be indicated if two adjacent cylinders are low on compression, or if air bubbles are detected in the cooling system.
5. Check out mechanical system engine noises.	5.

a.	Loose rods.	a.	Light knocking or pounding. The sound becomes more noticeable as accelerator is eased off with engine running at medium speed.
b.	Worn main bearings.	b.	Heavy, dull, metallic knock, most noticeable when the engine is under a heavy load or accelerating, especially when engine is cold. This noise is usually regular.
c.	Valve and tappet.	c.	This noise is usually a clicking noise. It could be caused from adjustment, weak springs, worn lifter faces, lifters loose, rough adjusting screw face, or rough cams.
d.	Piston pin.	d.	This noise may be similar to valve noise, but has a metallic double-knock characteristic. Usually more audible during idle with spark advanced and engine cold.
e.	Piston rings.	e.	This is normally clicking, snapping, or rattling noise. It is most evident on acceleration.
f.	Piston slap.	f.	Muffled, hollow, bell-like sound. It will be evidenced mostly when engine is cold.
6.	Have the instructor check the job.	6.	Instructor's initials: __________

Exercise 4

Locate and Correct System Troubles Without Special Test Equipment.

1.	If engine will not start, and the spark plug removed shows no sign of dampness on its base, perform a quick check of the fuel system on a designated engine.	1.	
a.	Remove air cleaner.	a.	This allows a view down into the carburetor. Caution: Never place your face close to carburetor opening when cranking engine.

b. Open and close the throttle manually and observe if fuel is present in the carburetor.	b. Throttle will operate the accelerator pump, which will push gasoline through the pump jet. If fuel is present, proceed to next check.
c. Check the choke valve (automatic and manual).	c. If engine is cold, choke valve should be closed (automatic choke). If choke valve will not close, the engine may be started, if gas is present at the carburetor, by holding hand over carburetor throat while cranking the engine.
2. Check the operation of the fuel pump on a designated engine.	2.
a. Disconnect the fuel lines from the fuel pump at the carburetor.	a. Care should be taken not to damage lines and fittings. Use the proper size tools, and use them correctly.
b. Crank engine over and observe if fuel pulsates from line.	b. If fuel does not pulsate from line during cranking, make further checks. Caution: Always make sure that precautions are taken to prevent gasoline from spilling on engine and floor.
c. Disconnect the line at the inlet side of pump.	c. Before blaming pump, check line by blowing through it and listen for gurgling sound in the tank. If line is open, the trouble is in the pump.
d. Check fuel pump sediment bowl and screen.	d.
e. Make sure no parts leak air.	e. If pump still does not work, remove and repair.

Exercise 5

Locate and Correct Charging System Malfunctions Without Sepcial Test Equipment.

1. Make a visual inspection of wires and connections in the charging system.	1. The ammeter can be checked by simply turning on lights and noting discharge.

2.	Check generator drive belt tension.	2.	Set as specified.
3.	Remove generator inspection cover and inspect brush contact and commutator condition. Note: If no cover band, inspect through end frame.	3.	Signs of thrown solder on cover indicates an overcharging or possibly a burned out generator.
4.	Check condition of battery.	4.	A shorted out battery does not take a charge.
5.	Make a current output test ("A" circuit) on engine.	5.	Before making any checks, determine whether the generator is grounded externally or internally.
a.	Make sure all lights or accessories are turned off.	a.	This does not apply if engine trainer is used.

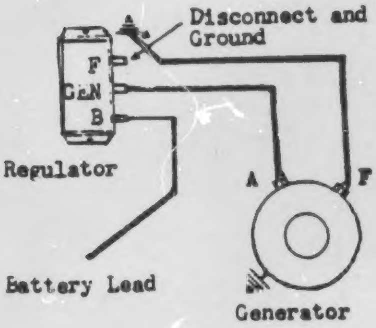

Figure 7. Connections for Making Generator Output Test ("A" Circuit).

b.	Make the proper hookup, figure 7.	b.	Warning: If lead is not disconnected from field terminal of double contact regulators, the upper set of contacts will burn instantly.
c.	Start engine and gradually increase its speed until ammeter indicates at least 25% above rated generator output.	c.	If generator does not produce its rated maximum output, check generator further to determine the cause of low output. If generator produces as specified, check regulator.
d.	Stop the engine.	d.	Caution: Remove test leads as soon as test is completed to prevent overheating generator.

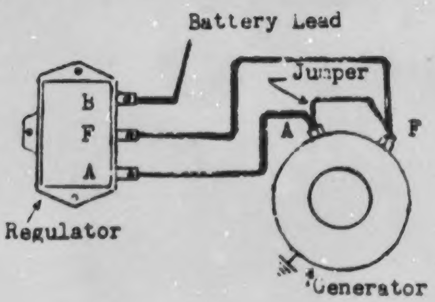

Figure 8. Connections for Making Generator Output Test ("B" Circuit).

6.	Perform a current output test ("B" circuit) on engine.	6.	
	a. Connect leads as shown in figure 8.		a. A jumper lead is connected from armature to field at the generator.
	b. Start engine and increase speed to approximately 1,500 rpm.		b. If generator is charging, trouble is in the current or voltage limiter. If there is no generator output, check the generator further.
	c. Stop engine and disconnect jumper.		c.
7.	Polarize the generator.	7.	After polarizing, reaccomplish output test. If still no charge, remove generator for disassembly and bench test.
	a. Disconnect armature lead at regulator and touch it to battery lead. Note: "B" circuit generators.		a.
8.	Have the instructor check the job.	8.	Instructor's initials: __________

Exercise 6

Locate and Service Cooling System Malfunctions Without Special Test Equipment.

1.	Check the hoses and connections.	1.	Hoses may deteriorate and collapse or become clogged to prevent adequate passage of coolant.

	Note: Check by squeezing the hoses by hand.		
2.	Check operation of thermostat(s).	2.	Run engine and observe temperature gauge. Engine should reach operating temperature within a short time. It should not overheat during operation.
3.	Check condition of coolant.	3.	Appearance of coolant may indicate rust and scale.
4.	Visually check radiator cores.	4.	
5.	Note the radiator pressure cap.	5.	Always be sure the correct cap is used.
6.	Have the instructor check the job.	6.	Instructor's initials: _________

Exercise 7

Locate and Service Lubricating System Malfunctions Without Special Test Equipment.

1.	Check the appearance of the oil on dipstick.	1.	Note whether it is thin, dirty, thick, or has sufficient body.
2.	Note oil pressure when engine is started.	2.	
3.	Note oil pressure after engine is normalized.	3.	
4.	Have the instructor check the projects.	4.	Instructor's initials: _________

Vehicle Maintenance Branch
Chanute AFB, Illinois

3ABR47330-WS-402

SCIENTIFIC TUNEUP OF MECHANICAL, BATTERY, IGNITION, FUEL LUBRICATION, COOLING, AND CRANKCASE VENTILATION SYSTEMS

OBJECTIVES

When you have completed the exercises in this worksheet you will be able to:

Recognize, isolate, and adjust engine performance of the engine mechanical systems, fuel air systems, starting systems, charging systems, and ignition systems by using the required test equipment, common handtools, and special tools.

Observe safety precautions and use applicable technical publications.

EQUIPMENT

Live Engine
Engine Analyzer
Mechanics Handtools
Special Tools

PROCEDURE

Using the worksheet as a guide for step-by-step procedures and important information, perform each task listed and read the information about it where applicable in the following exercises and as directed by the instructor.

Exercise 1

Inspect the Battery and Starting System.

1. Observe all safety precautions applying to the project.	1.
2. Obtain the necessary handtools and test equipment.	2. List equipment required.
3. Obtain the necessary technical publications.	3. List reference used.
4. Visually inspect the designated battery.	4.
a. Check battery top for dirt or acid.	a.
b. Check cell vents.	b. Make sure vents are open.

c. Check cell covers.	c. Cracks and warpage.
5. Take a specific gravity reading.	5. If electrolyte level is low, add water to the proper level, but do not attempt to test at this time, figure 9.

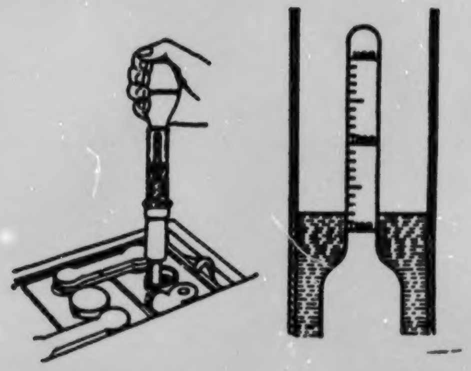

Figure 9. Taking Specific Gravity Reading of a Battery With Battery Hydrometer (A Closeup View of 1,280 Reading is Shown at The Right.)

a. Using battery hydrometer as shown in figure 9, remove sample of electrolyte from cell.	a. Remove enough fluid to allow float to remain clear of top and bottom of tester. Do not remove hydrometer from the cell.
b. Holding battery hydrometer upright, observe float reading at eye level.	b. This prevents the float from touching the side of tester.
c. Note the electrolyte temperature.	c. Add 4 points (.004) specific gravity to float reading for each 10 degrees above 80° F. Subtract 4 points (.004) specific gravity from float reading for each 10 degrees below 80° F.
d. Determine final float reading.	d. Reading obtained: Specified reading:
e. Using the above procedure, take reading of all cells and record readings in space provided.	e. Cell #1: Cell #2: Cell #3: Cell #4: Cell #5: Cell #6:

6. Service the battery.	6.
a. Neutralize acid.	a. Use a solution of baking soda and water.
b. Flush with water and thoroughly dry.	b. Make sure that none of the solution enters the battery.
c. Paint battery holddown and case.	c. Use acid-resistant paint which prevents corrosion.
d. Coat outside of battery terminal cables.	d. Use a thin coat of petrolatum jelly or vaseline. This retards corrosion.
7. Visually inspect the starting system of the designated starting system.	7.
a. Check cables.	a. Look for frayed insulation or broken strands.
b. Check all connections.	b. Check for looseness and corrosion.
c. Check the starting motor.	c. This is a visual check of the brushes, commutator, and mountings.
8. Have the instructor check the job.	8. Instructor's initials: ________

Exercise 2

Inspect and Service the Charging System.

1. Observe the applicable safety precautions.	1.
2. Obtain the necessary tools.	2.
3. Check the generator mountings.	3.
4. Check the belt(s).	4. Thoroughly check the condition. Make sure belt(s) has the correct tension. (Always refer to vehicle manual.) Record belt deflection: Record specified deflection:
5. Check the generator condition.	5. Visually check brushes, commutator condition, and internal cleanliness.
6. Check regulator mounting.	6.

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7. Check all wiring and connections.	7. Check for loose or corroded connections and condition of wires.
8. Service the designated charging system.	8. This consists of correcting any troubles found during the inspection of the system.
9. Have the instructor check the job.	9. Instructor's initials: __________

Exercise 3

Determine Condition of Engine Mechanical Systems.

Note: The basis of good performance depends on the condition of the engine. The following tests tell the experienced mechanic very much concerning the condition of the engine.

1. Determine all applicable safety precautions.	1.
2. Obtain the necessary tools and equipment.	2. List tools and equipment.
3. To insure safe damage-free operation, prior to starting the engine and performing tuneup of the engine, check the following items.	3.
a. Engine oil level.	a.
b. Coolant level.	b.
c. Fuel or oil leak.	c.
d. Lines, fittings and filters.	d.
e. Manifold heat control.	e.
f. Crankcase vent system.	f.
4. Operate engine until normal operating temperature is reached.	4.
5. Test compression on designated engine.	5. No hookup or specific procedures will be given at this time. Always use the procedures as given in the commercial manual applying to the test equipment being used. The student should use the note column for recording any notes pertaining to the tests that are actually made.

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			Type of equipment used: Reference used: Specified compression pressures: Readings obtained:
6.	From the following compression test indication determine the possible trouble.	6.	In the spaces provided below, give the possible trouble.
	a. Low compression on first stroke, builds up on following strokes, but never to specified amount. Improves when oil is added.		a. Possible trouble:
	b. Low compression on first stroke does not build up on following strokes even with oil added.		b. Possible trouble:
	c. Same indication as above on two adjacent cylinders.		c. Possible trouble:
	d. Compression pressure higher than specified.		d. Possible trouble:
7.	Perform cylinder leakage test.	7.	If certain test equipment is available, this test may be accomplished. However, if it is not available, disregard this project. This test is becoming very important and is made to determine the percentage of leakage in individual cylinders. Also, the leakage can be pinpointed to a certain location. Refer to test equipment manual for hook-up and testing procedures.
8.	Have the instructor check the job.	8.	Instructor's initials: ___________

Exercise 4

Perform a Visual Inspection, Service, and Install Spark Plugs.

1.	Observe applicable safety precautions.	1.	
2.	Obtain the necessary tools and equipment.	2.	List equipment required.

3. Obtain the applicable technical publications.	3. Reference used:
4. Visually check the gasket appearance and determine if plug was installed properly.	4. In the space provided below, explain what indicates the different plug installations.
a. Correct installation.	a. Indication:
b. Plug installed too loose.	b. Indication:
c. Plug installed too tight.	c. Indication:
5. Analyze the spark plug operating conditions by checking the insulator deposit or condition.	5.
6. Determine the spark plug serviceability.	6. Were spark plugs serviceable.
7. Inspect physical condition of spark plugs.	7.
a. Electrodes.	a. Record findings: Note: If electrodes are reasonably square, plugs may be serviced if other factors are correct.
b. Insulator.	b. Record finding:
c. Shell and insulator seals.	c. Record findings:
8. Service the spark plugs.	8.

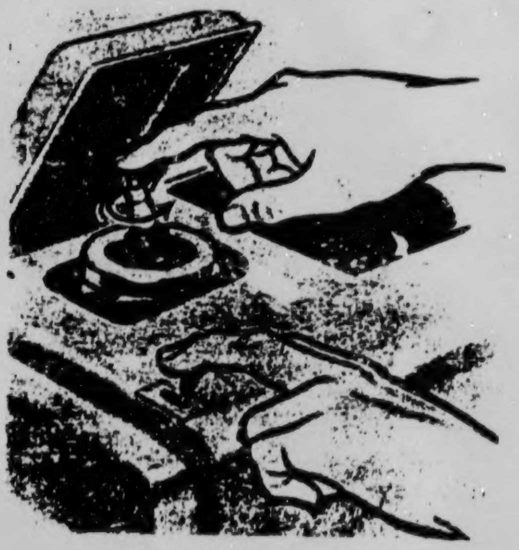

Figure 10. Cleaning Spark Plug.

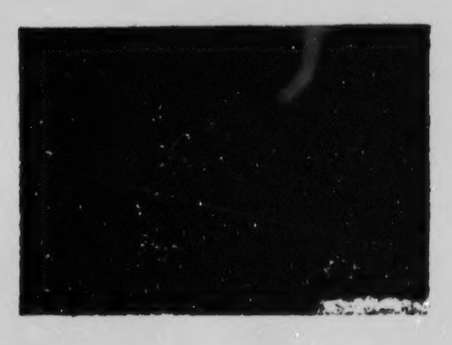

Figure 11. Filing Electrode.

a. Sandblast fireing end of plug, figure 10.	a. Do not overclean. Clean as instructed.
b. Clean upper insulator and threads.	b. Never use wire brush to clean insulator. Hand wire brush may be used to clean threads. Wipe upper insulator with cloth and solvent.
c. File electrodes, figure 11.	c. Use a point file. File electrodes until the gap area is flat.

Figure 12. Resetting Spark Gap, Using Spark Gapping Tool.

d. Set the spark gap, figure 12.	d. Set according to specifications. Note: Use suitable adjusting tool. Bend ground electrode only.
9. Install spark plugs in engine.	9. Clean seats, and on plugs which require gaskets, use new ones. Normally plug should be started into cylinder by fingers unless otherwise specified. Tighten plugs specified amount. Record specified torque.
10. Have the instructor check the job.	10. Instructor's initials: ___________

Exercise 5

Visually Inspect and Service the Primary Ignition Circuit.

1. Observe applicable safety precautions.	1.

2.	Obtain the necessary handtools and equipment.	2.	List tools and equipment.
3.	Obtain the necessary technical publications.	3.	Reference used:
4.	Check the primary ignition circuit connections.	4.	The connections are located at the distributor coil, primary terminals, resistor (when used), horn relay, ignition switch, and ammeter.
5.	Clean and tighten connections.	5.	
6.	Check circuit wiring.	6.	Repair or replace any faulty wiring.
7.	Have the instructor check the job.	7.	Instructor's initials: __________

Exercise 6

Visually Inspect the Ignition Distributor and Lubricate.

1.	Observe all applicable safety precautions.	1.	
2.	Obtain the necessary tools and equipment.	2.	
3.	Remove distributor cap and check the following:	3.	Normally two clips hold cap in place.
	a. Points.		a. A quick check can be made to determine if points are burned or pitted.
	b. Cam.		b. Damage may occur because of lack of proper lubrication. Check for evidence of burning or scoring.
	c. Leads.		c.
	d. Advance mechanism.		d. Check for looseness or tightness.
4.	Lubricate the distributor.	4.	Lubricate as specified by the manufacturer.
5.	Have the instructor check the job.	5.	Instructor's initials: __________

Exercise 7

Visually Inspect and Service Secondary Ignition Circuit.

1.	Observe all safety precautions applying to project.	1.	

2.	Obtain the necessary tools and equipment.	2.	List tools and equipment.
3.	Obtain the applicable technical publications.	3.	Reference used:
4.	Visually inspect the following:	4.	A close examination of the secondary circuit may uncover defects responsible for poor engine performance.
	a. Rotor.		a. Check for cracks, carbon tracks, and contact condition.
	b. Cap.		b. Same as for paragraph a.
	c. Cables.		c. Check condition - deteriorated insulation and corroded terminals.
	d. Coil.		d. Check for cracked or corroded tower terminal.
5.	Clean coil tower, high-tension wires, and inside of distributor cap.	5.	Use lint free cloth.
6.	Service or replace any defective parts.	6.	If item is found unsatisfactory, service as required.
7.	Have the instructor check the job.	7.	Instructor's initials: ___________

Exercise 8

Make a Visual Check and Service the Cooling System.

1.	Observe all applicable safety precautions.	1.	
2.	Obtain the necessary tools and equipment.	2.	List equipment required.
3.	Obtain the applicable publications.	3.	Reference used:
4.	Visually inspect the following cooling system components.	4.	A thorough inspection may show troubles responsible for engine trouble.
	a. Radiator.		a. Check for leaks, clogged air and water passages, and cleanliness.

b.	Water pump.	b.	Check for leaks.
c.	Hoses.	c.	After a period of time, hoses deteriorate, and may collapse or break. All connections should be checked.
d.	Water pump drive belt.	d.	Check for condition and amount of tension. Always set belt to manufacturer's specification.
5.	Service the cooling system.	5.	
6.	Have the instructor check the job.	6.	Instructor's initials: ___________

Exercise 9

Inspect and Service the Fuel and Exhaust System.

1.	Observe all safety precautions.	1.	
2.	Obtain the necessary tools, equipment, and publications.	2.	
3.	Check carburetor settings.	3.	This includes choke setting, idle speed and mixture, etc.
4.	Check carburetor for cleanliness and tightness of assembly screws.	4.	
5.	Check for fuel leakage at the carburetor.	5.	
6.	Check filter, lines, and connections of fuel system.	6.	
7.	Check fuel pump.	7.	This includes the mounting and leakage (fuel and oil).
8.	Heat control valve operation.	8.	Check for freeness, thermostatic spring, and counterweight.
9.	Check engine ventilation.	9.	
10.	Check the air cleaner.	10.	
11.	Check the complete exhaust system.	11.	
12.	Service the above components as required.	12.	Tighten all manifold bolts to specification.

13.	Have the instructor check the job.	13.	Instructor's initials: __________

Exercise 10

Perform the Tuneup Tests in Sequence, Using Test Equipment.

Note: The information included in this worksheet will serve as a guide for performing a tuneup on a vehicle. Because of the different types of test equipment that may be used, the test equipment manufacturer's instruction manual should be consulted for test procedures.

1.	Observe applicable safety precautions.	1.	
2.	Obtain the necessary tools and test equipment.	2.	List type of equipment used.
3.	Obtain the applicable publications.	3.	Reference used:
4.	Prepare equipment for use.	4.	The test equipment must be set up and connected according to manufacturer's recommendations.
5.	Warm up the designated engine.	5.	Engine operating temperature must be obtained before proceeding with test series.
6.	Perform the cranking voltage test.	6.	This test is made to determine the starting system condition and the voltage applied to the coil while cranking. The voltage should be high and cranking speed normal.
a.	Connect voltmeter.	a.	Connect positive lead to battery terminal ballast resistor and negative lead to a good ground.
b.	Connect a jumper wire to distributor terminal of coil and to ground on engine.	b.	
c.	With switch on, crank engine for approximately 15 seconds.	c.	
d.	Observe voltmeter reading and cranking speed and compare to specifications.	d.	Readings obtained: Voltmeter ________________ Cranking speed ___________ Specified readings: Voltmeter ______________ Cranking speed ___________

	Note: If the voltmeter reading is less than specified (9.0), or cranking is uneven or slow, the starting system or ignition primary circuit is faulty. In this case further tests are made in sequence.
e. If faulty conditions are indicated, perform the following tests to pinpoint troubles.	e. When making the following tests, always consult the test equipment manufacturer's manual for procedures.
(1) Battery high rate discharge test.	(1) Specific gravity must be 1.210 or higher, and electrolyte temperature 60° F or above.
(2) Starter amperage draw test.	(2) If amperage draw is below specifications, and cranking speed is slow, it indicates faulty brush or commutator, high resistance in field or armature circuit. If amperage draw is higher than specified, and cranking speed is slow, it indicates shorted circuits, armature rubbing pole shoes, or other mechanical drag.
(3) Starter insulated circuit test.	(3) When voltmeter reading exceeds .3 volt, high resistance in starter insulated circuit is indicated.
(4) Starter ground circuit test.	(4) If voltmeter reading exceeds .2 volt, it indicates excessive voltage loss in starter ground circuit.
(5) Ignition primary circuit test.	(5) A faulty ignition primary circuit is indicated by a reading which exceeds .2 volt and varies when switch is operated.

7.	Perform a distributor resistance test, using the procedures as outlined in the test equipment manufacturer's manual.	7.	This test indicates the condition of the ignition primary circuit from the coil through the distributor ground. If the reading is not as specified, pinpoint the high resistance as given in manufacturer's manual.
8.	Perform a dwell test as prescribed by the equipment manufacturer's manual.	8.	This test indicates the number of degrees of distributor cam rotation during time the points remain closed for each ignition cycle. If incorect dwell reading is obtained, incorrect point gap, defective cam, worn rubbing block or distorted breaker arm is indicated for pinpointing trouble, refer to distributor test section of applicable test equipment manual.
9.	Set the ignition timing, using necessary test equipment.	9.	The timing must be set to specifications. Use test equipment as specified by its manufacturer.
10.	Perform ignition advance test according to test equipment manufacturer's manual.	10.	This test indicates whether or not the distributor advance mechanism is advancing ignition timing as specified. Note: Test equipment for making this test may not be available. If not, disregard this project. If equipment is available, make test according to equipment manufacturer's manual.
a.	If reading is not within specified range, remove distributor.	a.	
b.	Inspect, service, test, and calibrate distributor, and reinstall.	b.	Refer to equipment manufacturer's manual for procedures of making distributor tests and calibration with distributor removed from engine.
11.	Perform a secondary circuit resistance test as prescribed by the test equipment manufacturer's instruction manual.	11.	This test indicates the amount and polarity of current reaching the spark plugs. If readings are uneven or less than specified, high resistance exists in the secondary circuit. To pinpoint the trouble if the test indicates faulty operation, refer to coil, condenser, and circuit tests in the applicable manual. These tests are made in sequence as given below.

12. Perform the ignition secondary insulation test as prescribed by the applicable test equipment instruction manual.	12. This test indicates coil output and condition of secondary circuit insulation. If test indicates faulty conditions, refer to coil, condenser, and circuit tests in applicable manual. Note: The following tests should be made in the sequence as given when the tests of the secondary circuit indicate need of further tests. Caution: Always conduct a thorough visual inspection before performing tests. Excessive rotor gaps account for low readings. This cannot be pinpointed with conventional test instruments.
a. Perform coil capacity test.	a. Conduct tests according to manufacturer's instruction manual.
b. Perform coil secondary resistance test.	b.
c. Perform secondary circuit insulation test.	c.
d. Perform circuit resistance test.	d.
e. Perform condenser resistance test.	e.
f. Perform condenser capacity test.	f. f.
g. Perform condenser leakage test.	g.
h. Perform coil primary and ballast resistor test.	h.
13. Perform a charging voltage test in accordance with the applicable instruction manual.	13. This test indicates the overall condition of the charging system. Refer to test equipment manufacturer's manual for procedures on testing and servicing.
14. Set the idle speed and mixture to specified settings.	14. Use test equipment manufacturer's manual for procedure on testing carburetor, intake manifold, valve timing and valve lift.

15. Disconnect test leads from vehicle.	15.
16. Have the instructor check the project.	16. Instructor's initials: ________

You have now completed the Field and Scientific Methods of Engine Troubleshooting and Tuneup, now you will further diagnose engine and power train performance by the use of the Chassis Dynamometer and the Universal Engine Analyzer.

Vehicle Maintenance Branch
Chanute AFB, Illinois

3ABR47330-WS-403

TUNEUP AND TROUBLESHOOTING USING DIAGNOSTIC TEST EQUIPMENT (SIMPSON UNIVERSAL ENGINE ANALYZER)

OBJECTIVES

Upon completion of this worksheet you will be able to:

Recognize, isolate, and adjust performance of the engine mechanical systems, battery starting and charging systems, ignition timing and coil testing, by using the Simpson Universal engine analyzer.

EQUIPMENT

Engine with all accessories
Simpson Universal engine analyzer
Handtools and special tools

PROCEDURE

Using the necessary tools, equipment and publications, complete the following exercises:

BATTERY AND STARTING SYSTEM TESTS

Preparation for Tests

1. Start engine and operate at fast idle with hood closed until engine and battery are at normal temperature. Stop engine.

2. Remove coil high tension wire from center terminal of distributor cap and ground to engine block.

3. Connect "Handi-Start" test leads to battery and starter relay or solenoid; red to insulated battery terminal and black to switch control terminal. Do not connect blue ignition lead or turn ignition switch on.

4. Connect "Battery Loader" ammeter and voltmeter test leads to battery posts; red to positive and black to negative.

Caution: Before connecting test leads to battery, be sure load control knob is in full counterclockwise position.

Note: When more than one battery is used, connect test leads to one battery only.

5. Set "VOLTS-AMPS" selector switch to "AMPS" position and voltage selector switch to "16 VOLTS" position.

Battery High Rate Discharge Test

1. Turn load control knob clockwise until meter reads the battery ampere-hour rating specified by the vehicle manufacturer.

2. Set "VOLT-AMPS" selector switch to the "VOLTS" positions. Meter should not read less than the specified minimum; 4.8 volts for 6-volt batteries or 9.6 volts for 12-volt batteries.

Caution: Do not exceed 15 seconds for discharge test.

3. Turn load control knob to full counterclockwise position and proceed with next test.

Note: When more than one battery is used, repeat steps 1, 2, and 3 for each battery.

Starter Amperage Draw Test

1. Using "Handi-Start," crank engine momentarily and observe exact voltage reading on meter while the engine is being cranked. Stop cranking.

2. Turn load control knob clockwise until the meter reads exactly the same voltage as when the engine was being cranked.

3. Set "VOLT-AMPS" selector switch to "AMPS" position and read meter for starter amperage draw. Unless otherwise specified, starter amperage draw should be within range indicated by green band marked "STARTER."

4. Turn load control knob to full counterclockwise position and proceed with next test.

Note: When more than one battery is used, it is only necessary to perform this test on one battery.

Battery Cable and Switch Test

1. Disconnect voltmeter lead from grounded battery post and connect to field terminal of starter motor.

2. Set "VOLT-AMPS" selector switch to "VOLTS" position.

Note: Voltmeter will read off-scale to right when system voltage is higher than 12 volts. This will not damage meter.

3. Using Handi-Start," crank engine while observing meter. Unless otherwise specified, voltmeter reading should not exceed the total of the following, depending on system voltage and number of components in circuit being tested.

   a. Each cable: 6-volt - .1 volt; 12-volt - .2 volt.

   b. Each switch: 6-volt - .1 volt; 12-volt - .1 volt.

   c. Each connection: 6-volt - .0 volt; 12-volt - .0 volt.

Note: For 24-volt system, refer to applicable technical order or manual.

Starter Control Circuit Test

1. Disconnect voltmeter lead from field terminal of starter motor and connect to switch control terminal of starter relay or solenoid.

2. Using vehicle's starter switch, crank engine while observing meter. Unless otherwise specified, voltmeter reading should not exceed 0.5 volts.

Starter Ground Circuit Test

1. Disconnect voltmeter lead from control terminal of starter relay or solenoid and connect to grounded battery post.

2. Disconnect voltmeter lead from insulated battery post and connect to housing of starter motor.

3. Using "Handi-Start," crank engine while observing meter. Unless otherwise specified, voltmeter reading should not exceed 0.2 volts.

4. Disconnect all "Battery Loader" and "Handi-Start" test leads and reconnect coil high tension wire to center terminal of distributor cap.

CHARGING SYSTEM TESTS

Preparation of Tests

1. Start engine and operate at fast idle with hood closed until charging system is at normal operating temperature. Stop engine.

2. Disconnect battery and field wires from regulator battery and field terminals.

Note: On waterproof charging systems, disconnect generator cable at generator and connect generator adapter FSN 4910-092-9026, to generator and disconnected cable. Also, disconnect battery cable at regulator and connect regulator adapter FSN 4910- 92-9025 to regulator and disconnected battery cable. Set battery and field terminal connector links to the "OPEN" position and armature connector link to the "CLOSED" position.

3. Connect "CHARGING-BATTERY-STARTER TESTER" ammeter, voltmeter and field test leads as follows:

a. Red ammeter lead to regulator battery terminal and black to disconnected battery wire.

b. Red voltmeter lead to regulator armature terminal and black to regulator base or ground.

c. One field lead to disconnect field wire and other to regulator armature terminal when generator field is grounded internally or to ground when generator field is grounded externally.

Note: On waterproof systems, connect red ammeter lead to regulator adapter #2 battery terminal and black to #1 terminal. Connect red voltmeter lead to generator adapter #1 armature terminal and black to regulator base or ground. Connect field leads to generator adapter #1 field terminal and #2 armature terminal. To connect ammeter leads to heavy duty or waterproof charging systems, use the Mueller #21C copper battery clips provided and connect the leads to the clips.

4. Set "VOLTAGE REGULATOR TEST" switch to the "DIRECT" position.

5. Turn "FIELD CONTROL" to the "OPEN" position.

6. Turn "TEST SELECTOR" switch to the "80 AMP" position.

7. Set "METER REVERSE" switch to the left-hand position for negative ground systems; to the right-hand position for positive ground systems.

8. Connect tachometer to engine as outlined in paragraph 3a(5) of this worksheet.

Generator Output Test

1. Start engine and adjust speed to 1500 rpm or to speed specified for generator output test.

2. Turn "FIELD CONTROL" to the "DIRECT" position. Observe meter reading and compare to specifications for generator output. Unless otherwise specified, generator output should equal or exceed that specified for current regulator setting.

Cutout Relay Test

1. Turn "FIELD CONTROL" toward the "OPEN" position until meter reads 5 amperes.

2. Set "METER REVERSE" switch so meter reads off-scale to the left of zero.

3. Continue to turn "FIELD CONTROL" toward the "OPEN" position while observing meter for current required to open cutout relay contacts. Compare to specifications for cutout relay opening amperage.

Note: Opening amperage is the maximum meter reading obtained before the pointer returns to zero.

4. Return "METER REVERSE" switch to original position.

5. Turn "TEST SELECTOR" switch to:

   a. "8-VOLT" position for 6-volt system.

   b. "16-VOLT" position for 12-volt system.

   c. "40-VOLT" position for 24-volt system.

6. Turn "FIELD CONTROL" toward "DIRECT" position while observing meter for voltage required to close cutout relay contacts. Compare to specifications for cutout relay closing voltage.

a. Closing voltage is the highest meter reading obtained just before pointer deflects slightly downscale.

b. If difficulty is encountered in determining cutout relay closing voltage at 1500 rpm, reduce engine speed to 800-1000 rpm.

c. For other than three-unit regulators, refer to applicable technical manual.

7. Turn "FIELD CONTROL" to the "OPEN" position.

Voltage Regulator Test

1. Disconnect field lead from regulator armature terminal or ground and connect to regulator field terminal.

Note: On waterproof systems, disconnect field lead from generator adapter #2 armature terminal and connect to #3 field terminal.

2. On charging systems where generator field is grounded externally, disconnect red voltmeter lead from regulator armature terminal and connect to battery terminal.

3. Set "VOLTAGE REGULATOR TEST" switch to the "TEST" position.

4. Adjust engine speed to 1500 rpm or to speed specified for voltage regulator test.

5. Turn "FIELD CONTROL" to the "DIRECT" position and allow meter reading to stabilize. Observe final meter reading and compare to specifications for voltage regulator setting.

a. On heavy-duty or waterproof charging systems, disconnect red ammeter lead from regulator battery terminal.

b. For double contact regulators, refer to applicable technical order or manual.

6. Turn "FIELD CONTROL" to the "OPEN" position.

Current Regulator Test

1. Set "VOLTAGE REGULATOR TEST" switch to the "DIRECT" position.

2. Turn "TEST SELECTOR" switch to the "80 AMP" position.

Note: Reconnect red ammeter lead to regulator battery terminal if disconnected in previous test.

3. Turn "FIELD CONTROL" to the "DIRECT" position.

4. Adjust engine speed to 1500 rpm or to speed specified for current regulator test.

5. Turn on all vehicle lights and accessories. Observe meter reading and compare to specifications for current regulator setting.

Note: If lights and accessories do not provide sufficient load for current regulator test, omit step 5 and connect "Battery Loader" to vehicle battery as outlined in paragraph 1, of this worksheet. Load battery until highest reading is obtained on the 0-80 ampere scale. This is the current regulator setting.

Regulator and Accessory Ground Circuit Voltage Loss Test

1. Disconnect red voltmeter lead from regulator armature or battery terminal and connect to regulator base.

Note: On waterproof systems, disconnect red voltmeter lead from generator adapter #1 armature terminal and connect to regulator base.

2. Disconnect black voltmeter lead from regulator base or ground and connect to generator housing.

3. Adjust engine speed to 800-1000 rpm.

4. Turn "TEST SELECTOR" switch to the "4-VOLT" position.

5. Turn on all vehicle lights and accessories. Observe meter reading and compare to specifications for regulator and accessory ground circuit voltage loss. Unless otherwise specified, voltmeter reading should not exceed 0.2 volts.

6. Turn all vehicle lights and accessories off and turn "FIELD CONTROL" to the "OPEN" position.

Ground Circuit Voltage Loss Test

1. Disconnect red voltmeter lead from regulator base and connect to grounded battery post.

2. Disconnect field lead from regulator field terminal and connect to regulator armature terminal when generator field is grounded internally or to ground when generator field is grounded externally.

Note: On waterproof systems, disconnect field lead from generator adapter #2 field terminal and connect to #2 armature terminal.

3. Turn "TEST SELECTOR" switch to the "80 AMP" position and turn "FIELD CONTROL" toward the "DIRECT" position until ammeter reads exactly 20 amperes.

4. Turn "TEST SELECTOR" switch to the "4-VOLT" position. Observe meter reading and compare to specifications for ground circuit voltage loss. Unless otherwise specified, voltmeter reading should not exceed 0.1 volts.

Insulated Circuit Voltage Loss Test

1. Disconnect red voltmeter lead from grounded battery post and connect to generator armature terminal.

Note: On waterproof systems, disconnect red voltmeter lead from grounded battery post and connect to generator adapter #1 armature terminal.

2. Disconnect black voltmeter lead from generator housing and connect to insulated battery terminal.

3. With charge rate adjusted to 20 amperes and "TEST SELECTOR" switch in the "4-VOLT" position, observe meter reading and compare to specifications for insulated circuit voltage loss. Unless otherwise specified, voltmeter reading should not exceed 1.0 volt.

4. Turn "FIELD CONTROL" to the "OPEN" position.

Generator Field Current Draw Test

1. Disconnect red voltmeter lead from generator armature terminal and connect to generator field terminal when generator field is grounded internally. Leave red voltmeter lead connected to generator armature terminal when generator field is grounded externally.

Note: On waterproof systems, disconnect red voltmeter lead from generator adapter #1 armature terminal and connect to #1 field terminal.

2. Disconnect black voltmeter lead from insulated battery post and connect to generator housing when generator field is grounded internally or to generator field terminal when generator field is grounded externally.

3. Turn "TEST SELECTOR" switch to:

a. "8-VOLT" position for 6-volt system.

b. "16-VOLT" position for 12-volt system.

c. "40-VOLT" position for 24-volt system.

4. Turn "FIELD CONTROL" toward "DIRECT" position until meter reads voltage specified for generator field current draw.

5. Turn "TEST SELECTOR" switch to the "FIELD CURRENT" position.

6. Observe meter reading and compare to specifications for generator field current draw.

Note: If meter reads off-scale to the left of zero, change position of "METER REVERSE" switch.

7. Reduce engine speed to idle, stop engine and disconnect all test leads from vehicle. Reconnect field and battery wires to regulator.

IGNITION SYSTEM TESTS

Preparation for Tests

1. Start engine and operate at fast idle with hood closed until engine is at normal temperature. Stop engine.

2. Disconnect spark plug cables at spark plugs and connect spark plug connectors to spark plugs. Connect cables to spark plug connectors.

> Note: On waterproof systems, disconnect spark plug cable at #1 spark plug and connect high-tension adapter, FSN 4910-356-7504, to spark plug. Connect disconnected cable to adapter. Loosen cable retaining nuts at all remaining spark plugs, but do not disconnect cables.

3. Connect "Handi-Start" test leads to starting and ignition systems; red to insulated battery post, black to switch control terminal of starter relay or solenoid and blue to battery terminal of ignition coil or resistor.

> Note: On waterproof systems, disconnect primary cable at distributor and connect ignition unit adapter, FSN 4910-356-7508, to distributor. Connect primary cable to adapter and blue test lead to exposed terminal.

4. Connect jumper lead to generator armature terminal and ground.

> Note: On waterproof systems, disconnect generator cable at regulator.

5. Connect "TACH-DWELL-IGNITION TESTER" test leads to ignition coil and ground; red to distributor terminal and black to engine block. Reverse connections for positive ground systems.

> Note: On waterproof systems, remove access plug from distributor cover and install distributor primary adapter, FSN 4910-356-7492. Connect red test lead to adapter.

6. Turn "CYLINDER SELECTOR" switch to:

   a. "8" for 8-cylinder engines.

   b. "6" for 6-cylinder engines.

   c. "4" for 4-cylinder engines.

7. Turn "TEST SELECTOR" switch to the "CALIBRATE" position and adjust "CALIBRATE" control until meter reads on "CALIBRATE" line at right-hand end of scale.

8. Set "VOLTAGE SELECTOR" switch to the "6" and "12 VOLT" or "24 VOLT" position depending on voltage rating of system being tested.

Point Resistance Test

1. Turn "TEST SELECTOR" switch to the "POINT RESISTANCE" position.

2. Turn "HANDI-START" ignition switch to the "ON" position.

3. Start engine and operate at idle speed. Meter should read in the green band of the "POINT RESISTANCE TEST" scale.

Dwell Test

1. Turn "TEST SELECTOR" switch to the "DWELL" position.

2. Observe meter reading and compare to specifications for distributor point dwell.

Note: Use lower scale for 4-cylinder engines.

Dwell Variation Test

1. Slowly increase engine speed to 1500-2000 rpm while observing meter for any change. Unless otherwise specified, dwell should not vary more than three degrees.

   Note: Some distributors are designed to change the dwell more than three degrees. Refer to distributor specifications for vehicle being tested.

2. Reduce engine speed to idle.

Engine Idle Speed Test

1. Turn "TEST SELECTOR" switch to the "250-650 RPM" position.

2. Place transmission shift lever in recommended position.

3. Observe meter reading and compare to specifications for engine idle speed.

   Caution: Place transmission shift lever in neutral position before continuing with tests.

Ignition Miss Test

1. Turn vehicle ignition switch to the "ON" position and "Handi-Start" ignition switch to the "OFF" position.

   Note: Vehicle ignition switch must be used for balance of tests, otherwise erroneous results will be obtained.

2. Turn "TEST SELECTOR" switch to the "IGNITION OUTPUT" position.

3. Accelerate and decelerate engine quickly while observing meter reading. Meter pointer should remain on zero.

   Note: On some ignition systems a slight pointer deflection, less than a meter reading of one (1), is normal.

Ignition Output Test

1. Turn "TEST SELECTOR" switch to the "0-5000 RPM" position.

2. Adjust engine speed to 1500 rpm.

3. Turn "TEST SELECTOR" switch to the "IGNITION OUTPUT" position.

4. Using insulated pliers, disconnect any one spark plug cable from spark plug and observe meter reading. Meter should read steady in the green band of the "IGNITION OUTPUT TEST" scale.

5. Reconnect spark plug cable to spark plug.

6. Repeat steps 4 and 5 on all remaining spark plug cables.

Secondary Current Test

1. Disconnect test leads from ignition coil and ground and connect red lead to ground.

Note: Always ground red lead for this test regardless of electrical system ground polarity.

2. Turn "TEST SELECTOR" switch to the "SECONDARY CURRENT-VOLTMETER" position.

3. Connect black lead to any one spark plug and observe meter reading. Meter should read in the green band of the secondary current test scale.

4. Repeat step 3 on all remaining spark plugs.

5. Disconnect test leads from spark plug and ground.

6. Reduce engine speed to idle and turn vehicle ignition switch to "OFF" position.

7. Disconnect jumper lead from generator armature terminal and ground.

Note: On waterproof systems, reconnect generator cable to regulator.

Cranking Voltage Test

1. Connect test leads to ignition coil and ground; red to battery terminal and black to engine block. Reverse connections for positive ground systems.

Note: On waterproof systems, connect red lead to exposed terminal on ignition unit adapter.

2. Connect jumper lead to distributor terminal of ignition coil and ground.

Note: On waterproof systems, connect jumper lead to distributor primary adapter and ground.

3. Turn vehicle ignition switch to the "ON" position and crank engine using "Handi-Start."

4. Observe meter reading and compare to specifications for cranking voltage. Unless otherwise specified, cranking voltage should not be less than 4.5 volts for 6-volt systems or 9.0 volts for 12-volt systems.

5. Turn vehicle ignition and "CYLINDER SELECTOR" switches to the "OFF" position and disconnect all test and jumper leads from vehicle.

6. Remove spark plug connectors from spark plugs and reconnect cables to spark plugs.

Note: On waterproof systems, remove all adapters, reconnect all cables and replace access plug in distributor cover.

IGNITION TIMING AND SPARK ADVANCE TESTS

Preparation for Tests

1. Turn "TACHOMETER ADVANCE TESTER TEST SELECTOR" switch to the "OFF" position.

2. Connect battery leads to 12-volt battery; red to positive post and black to negative post.

3. Connect spark plug pickup into #1 spark plug circuit at spark plug or distributor cap. Use adapter leads if necessary.

4. When distributor is equipped with a vacuum advance mechanism, disconnect vacuum line at carburetor and seal opening to spark port.

Ignition Timing Test

1. Turn "TEST SELECTOR" switch to the 0-1000 rpm position.

2. Start engine and adjust speed to that specified for ignition timing.

Note: Some manufacturers specify that engine speed be set to a speed higher or lower than that specified for idle. Always refer to specifications concerning vehicle being tested before attempting to check or adjust ignition timing.

3. Turn "TEST SELECTOR" switch to the "TIMING LIGHT" position.

4. Aim timing light at timing pointer and observe position of timing mark in relation to timing pointer. Compare to specifications and adjust if necessary.

5. Reconnect distributor vacuum line and proceed with next test.

Spark Advance Test

1. Turn "TEST SELECTOR" switch to the 0-5000 rpm position.

2. Refer to distributor specifications for vehicle being tested.

3. Select a speed specified for centrifugal or governor advance which, when multiplied by two, will be as high as possible but not exceed 2500 engine rpm; ie, if distributor specifications state that spark should avance 11 - 13 degrees at 1100 rpm, multiply by two; or 2200 engine rpm.

Note: Specifications for centrifugal or governor advance are usually stated as distributor speed and degrees. If specification is stated as engine speed and degrees, select speed as instructed, but do not multiply.

4. Adjust engine speed to specification selected.

5. Turn "TEST SELECTOR" switch to the "ADVANCE" position.

6. Aim timing light at timing pointer and adjust advance control until timing mark is aligned with pointer.

Note: Advance control is located in timing light housing.

7. Observe meter reading and compare to specifications.

Note: If distributor has both cnetrifugal and vacuum advance mechanisms, meter should read specified centrifugal advance, plus specified maximum vacuum advance.

8. Adjust engine speed to that specified for idle. Stop engine.

9. Turn test selector to the "OFF" position and disconnect all leads.

COIL TESTS

Preparation for Tests

1. Turn "CONDENSER-MAGNETO ANALYZER TEST" selector switch to the "OFF" position.

2. Connect battery leads to 12-volt battery; red to positive post and black to negative post.

Note: Battery leads have plier-type clips.

3. For on-the-vehicle tests, disconnect all wires from the coil.

Note: When bench testing coils having nonmetallic cases, the coil must be at least four inches away from any metal object, including metal bench top. Magneto coils must be mounted on their iron cores but removed from the stator unless otherwise specified.

Coil Secondary Resistance Test

1. Turn "TEST SELECTOR" switch to the "COIL RESISTANCE" position.

2. Connect test leads to coil; red to either primary terminal and black to secondary terminal.

Note: Use test clip or prod as required.

3. Observe meter reading and compare to specifications for coil secondary winding resistance. Unless otherwise specified, meter reading should be in the green band of the "COIL RESISTANCE TEST" scale, and not exceed 20,000 ohms.

Note: To obtain resistance value, multiply meter reading by 1000.

Coil Insulation Test

1. Turn "TEST SELECTOR" switch to the "COIL SET" position.

2. Disconnect black lead from secondary terminal and connect to other primary terminal. Use test clip, not prod.

3. Turn "COIL INDEX" control to specified position and adjust set control until meter indicates value specified for coil set. Refer to specification chart.

Note: If no meter reading is obtained or specified setting cannot be reached, coil primary winding is faulty.

4. Turn "TEST SELECTOR" switch to the "COIL TEST" position. Meter should read steady and in the green band of the "COIL TEST" scale. (Meter should not vary more than one major division.)

5. During coil insulation test and using black test prod, probe the areas between the primary and secondary terminals for leakage. Meter reading should remain in green band of "COIL TEST" scale.

Note: When bench testing metal cased coils, also touch prod to case. Meter reading should remain in green band of "COIL TEST" scale.

6. Turn "TEST SELECTOR" switch to the "OFF" position and disconnect battery and test leads.

CONDENSER TESTS

Preparation of Tests

1. Turn "CONDENSER-MAGNETO ANALYZER TEST" selector switch to the "OFF" position.

2. Connect battery leads to 12-volt battery; red to positive post and black to negative post.

Note: Battery leads have plier-type clips.

3. For on-the-vehicle tests, disconnect primary wire at coil or distributor and install fiber block between breaker lever and cam.

Note: On waterproof systems, remove distributor cover and disconnect distributor lead from coil.

4. Turn "TEST SELECTOR" switch to the "CONDENSER RESISTANCE" position.

5. Connect red and black test leads together and adjust set control until meter reads on set line at righ-hand end of "CONDENSER RESISTANCE TEST" scale.

Note: Allow approximately 30 seconds for tester to warm up before attempting to calibrate.

Condenser Resistance Test

1. Separate test leads and connect to distributor housing and primary terminals or lead. Meter should read in the green band of the "CONDENSER RESISTANCE TEST" scale.

Note: When bench testing condenser, connect test leads to condenser case and pigtail lead.

2. During condenser resistance test, move condenser pigtail lead back and forth while observing meter for any change. Meter reading should remain steady in green band of "CONDENSER RESISTANCE TEST" scale.

Condenser Leakage Test

1. Turn "TEST SELECTOR" switch to "CONDENSER LEAKAGE" position.

2. Observe meter reading. Meter should read in the green band of the "CONDENSER LEAKAGE TEST" scale.

Condenser Capacity Test

1. Turn "TEST SELECTOR" switch to "CAPACITY" position.

2. Observe meter reading and compare to specifications. Condenser capacity should be within range specified by manufacturer.

Note: Meter reading indicates condenser capacity in microfarads (mfd).

3. Turn "TEST SELECTOR" switch to the "OFF" position and disconnect battery and test leads.

FUEL AND VACUUM BOOSTER PUMP TESTS

Preparation for Tests

1. Start engine and operate at fast idle with hood closed until engine and fuel system are at normal temperature. Stop engine.

2. Remove carburetor air cleaner and disconnect fuel line at carburetor inlet.

Note: When more than one carburetor is used, disconnect fuel line at tee connection or junction.

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3. Connect fuel pump tester inlet to disconnected fuel line.

Caution: Be sure inlet hose is securely connected to fuel line. If necessary, move retaining nut away from end of fuel line to prevent interference with inlet hose.

4. Connect tachometer to engine as outlined in paragraph 3a(5) of this worksheet.

Fuel Pump Pressure Test

1. Start engine and operate at idle speed or speed specified for fuel pump pressure test.

2. Observe pressure gauge reading and compare to specifications for fuel pump pressure.

Fuel Pump Volume Test

1. With engine operating at idle speed or speed specified for fuel pump volume test, direct tester discharge hose into a suitable fuel container.

2. Press "CAPACITY TEST" button down and observe fuel gauge reading. Compare to specifications for fuel pump capacity or volume.

3. Release "CAPACITY TEST" button.

4. Stop engine and disconnect tester inlet hose from fuel line. Reconnect fuel line to carburetor inlet or tee connection and replace air cleaner.

Fuel Pump Vacuum Test

1. Disconnect fuel inlet and outlet lines from fuel pump.

2. Connect fuel pump tester inlet hose to pump inlet.

Note: If necessary, remove fitting or flexible hose from fuel pump and use 1/8" pipe adapter furnished.

3. Start engine and operate at idle speed or speed specified for fuel pump vacuum test until highest vacuum gauge reading is obtained.

4. Observe final gauge reading and compare to specifications for fuel pump vacuum. Unless otherwise specified, fuel pump vacuum should not be less than 10.0 inches.

5. Stop engine and observe vacuum gauge for about 15 seconds. Vacuum reading should remain constant and not decrease after engine is stopped.

6. Disconnect tester inlet hose from fuel pump and reconnnect fuel lines to fuel pump.

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Vacuum Booster Pump Test

1. Disconnect manifold vacuum line from booster pump outlet.

2. Disconnect windshield wiper hose from booster pump inlet and connect fuel pump tester inlet hose to pump inlet.

3. Start engine and operate at 1000 rpm or speed specified for vacuum booster pump test.

4. Observe vacuum gauge reading and compare to specifications for vacuum booster pump test. Unless otherwise specified, vacuum should not be less than 7.0 inches.

5. Stop engine and disconnect tester inlet hose from vacuum booster pump. Reconnect windshield wiper hose and manifold vacuum line to vacuum booster pump.

ENGINE COMPRESSION AND VACUUM TESTS

Preparation for Tests

1. Start engine and operate at fast idle until engine is at normal temperature. Stop engine.

2. Disconnect spark plug cables from spark plugs and loosen each spark plug about one turn.

3. Reconnect spark plug cables to spark plugs.

4. Start engine and accelerate briefly to remove loosened carbon from combustion chambers.

5. Stop engine and disconnect spark plug cables from spark plugs.

6. Using compressed air, blow all foreign matter from spark plug wells. Remove all spark plugs.

7. Remove coil high-tension cable from center terminal of distributor cap and ground to engine block.

8. Connect "Handi-Start" test leads to battery and starter relay or solenoid; red to insulated battery post and black to switch control terminal. Do not connect blue lead or turn on ignition switch.

Compression Test

1. Screw cylinder analyzer compression gauge hose adapter into spark plug opening and connect coupler to gauge. Tighten by hand only. Do not use tools.

Note: For engines with spark plug threads recessed in cylinder head, use long-reach adapter.

2. Using "Handi-Start," crank engine until highest compression gauge reading is obtained. Record results and compare to specifications for compression pressure.

3. Push "PRESSURE RELEASE" button down to vent gauge. Disconnect coupler from gauge and remove hose adapter from spark plug opening.

4. Repeat steps 1, 2, and 3 on all remaining cylinders in engines.

Vacuum Test

1. Connect cylinder analyzer vacuum gauge hose to gauge coupler and cylinder adapter handle.

2. Select short or long-reach cylinder adapter, as required, and attach to handle.

Note: For deeply recessed spark plug openings, use extension.

3. Push cylinder adapter into spark plug opening and crank engine, using "Handi-Start," until highest vacuum gauge is obtained. Record results.

Note: Compression pressure will be exhausted through vents in cylinder adapter handle when engine is being cranked.

4. Push "VACUUM RELEASE" button down to vent gauge.

5. Repeat steps 3 and 4 on all remaining cylinders in engine.

6. Determine cylinder condition by comparing compression and vacuum gauge readings to analysis chart.

7. Disconnect "Handi-Start" test leads and reconnect coil high-tension cable to center terminal of distributor cap.

8. Replace spark plugs and reconnect spark plug cables to spark plugs.

Vehicle Maintenance Branch
Chanute AFB, Illinois

TROUBLESHOOTING, DIAGNOSIS, AND REPAIR OF LIGHTING, WARNING AND SIGNAL SYSTEMS AND HEADLIGHT TESTING

OBJECTIVES

When you have completed the frames in this worksheet you will be able to:

Troubleshoot lighting, warning, and signal systems on a vehicle.

Diagnose lighting, warning and signal system troubles.

Perform tasks related to vehicle operation to accomplish troubleshooting.

Use tools, test equipment, and applicable publications.

EQUIPMENT

Live vehicle
Voltmeter
Ammeter
Continuity light
Battery hydrometer

PROCEDURE

Use this guide while troubleshooting the vehicle circuitry along with the test equipment and handtools with which you have been provided.

To use this guide:

1. Operate, or attempt to operate the system.

2. Determine the symptom(s).

3. Find the symptom(s) in the table of contents.

4. Turn to the frame in the guide to which the index refers you.

5. Check out each possibility shown on the flow chart, for the conditions that exist, until you locate the trouble.

Note: A typical circuit schematic is shown for each system at the bottom of most of the frames. They may not be identical to the system you are working on, but they will be similar. Use these schematics as needed to assist you in troubleshooting. This guide does not always tell you what to do, but it will give you a logical sequence to follow in locating troubles. Use the applicable vehicle shop manual for the necessary "what" and "how to do" information, and any specifications and details you may want or need.

TABLE OF CONTENTS

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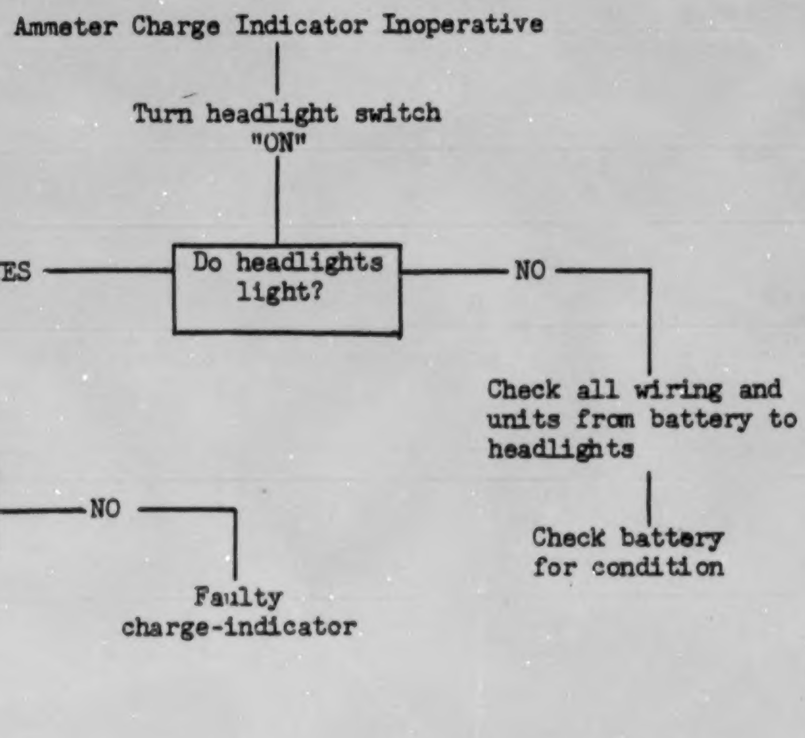
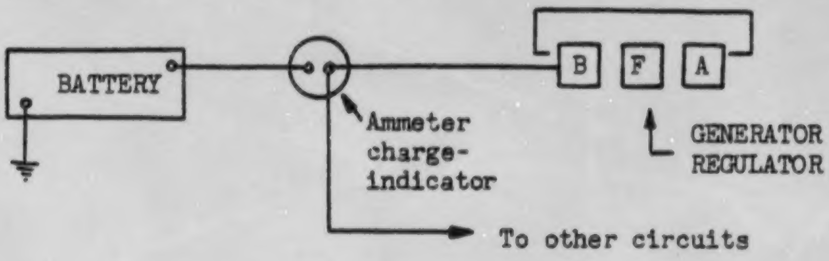
Frame 1.


Ammeter Charge Indicator Inoperative
Turn headlight switch "ON"
Do headlights light?
YES
NO
Headlights "ON"
Does ammeter show discharge?
NO
YES
System Okay
Faulty charge-indicator
Check all wiring and units from battery to headlights
Check battery for condition


BATTERY
Ammeter charge-indicator
B
F
A
GENERATOR REGULATOR
To other circuits

TYPICAL CIRCUIT SCHEMATIC

Frame 2.

Battery Low in Charge

Check Cables for Corrosion

Check Terminals for Security

Check Case for Cracks

Check Electrolyte for Proper Level

Check Electrolyte of Each Cell for
Specific Gravity*

Charge Battery

Replace the battery if it is in such poor condition that it will not take or hold a charge.

* Record these specific gravity readings in the space provided on the worksheet.

Frame 3.

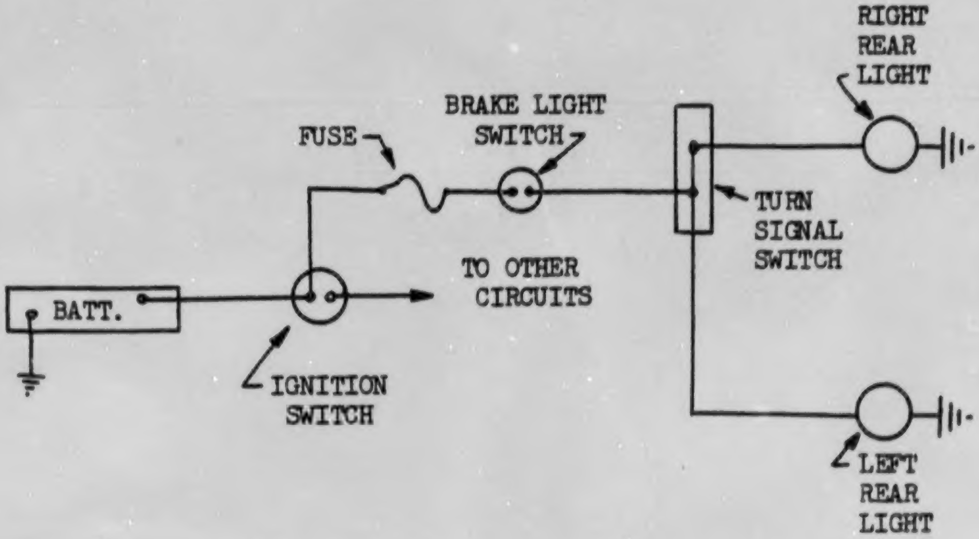
Brake Lights Inoperative

Check Brake Light Switch

Check for Blown Fuse

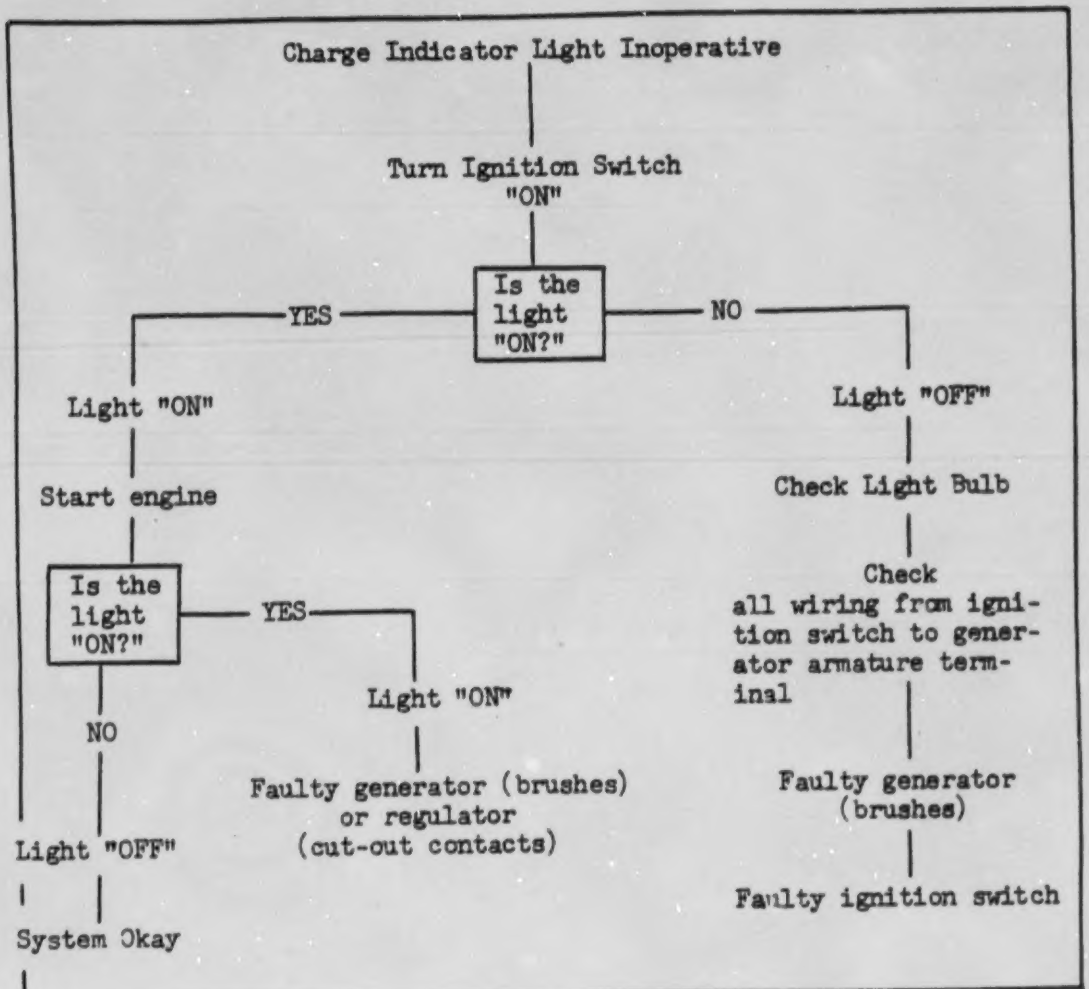
Check All Wiring

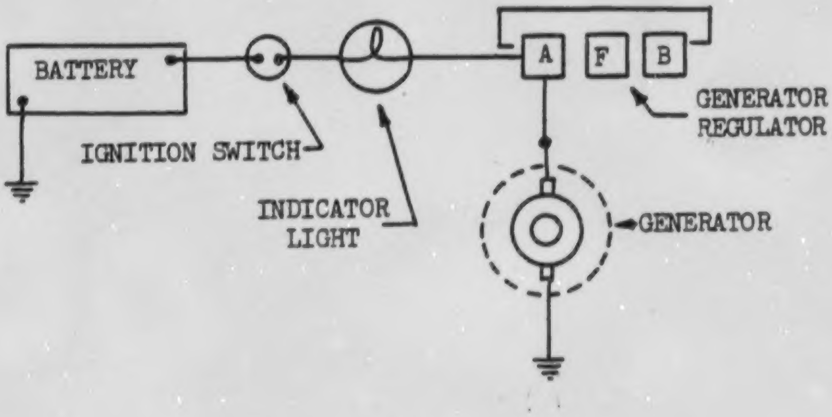
Check for Burned Out Bulbs


RIGHT REAR LIGHT
FUSE
BRAKE LIGHT SWITCH
TURN SIGNAL SWITCH
TO OTHER CIRCUITS
BATT.
IGNITION SWITCH
LEFT REAR LIGHT

TYPICAL CIRCUIT SCHEMATIC

Frame 4.


Charge Indicator Light Inoperative
Turn Ignition Switch "ON"
Is the light "ON?"
YES
NO
Light "ON"
Start engine
Is the light "ON?"
YES
Light "ON"
Faulty generator (brushes) or regulator (cut-out contacts)
NO
Light "OFF"
System Okay
Light "OFF"
Check Light Bulb
Check all wiring from ignition switch to generator armature terminal
Faulty generator (brushes)
Faulty ignition switch


BATTERY
IGNITION SWITCH
INDICATOR LIGHT
A
F
B
GENERATOR REGULATOR
GENERATOR

TYPICAL CIRCUIT SCHEMATIC

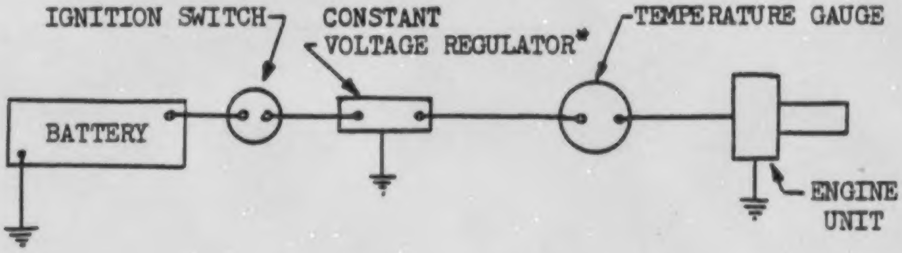
Engine Temperature Gauge Inoperative

Check All Wiring

Defective Temperature Gauge

Defective Engine Unit

Defective Constant Voltage Regulator


IGNITION SWITCH
CONSTANT VOLTAGE REGULATOR*
TEMPERATURE GAUGE
BATTERY
ENGINE UNIT

TYPICAL CIRCUIT SCHEMATIC

Frame 6.

Fuel Gauge Inoperative

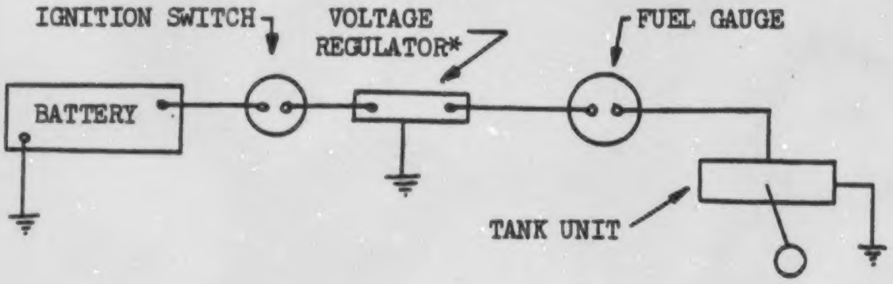
Check All Wiring

Check Fuel Tank Ground to Body

Defective Fuel Gauge

Defective Tank Unit

Defective Constant Voltage Regulator


IGNITION SWITCH
VOLTAGE REGULATOR*
FUEL GAUGE
BATTERY
TANK UNIT

TYPICAL CIRCUIT SCHEMATIC

Frame 7.

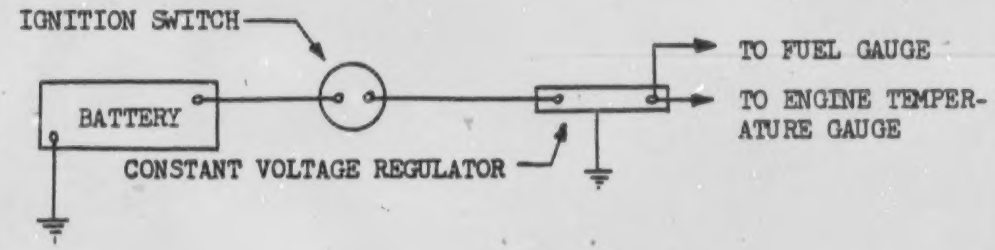
Fuel and Temperature Gauges Inoperative

Check Voltage Regulator Ground

Check Wiring to Fuel and Temp Gauges

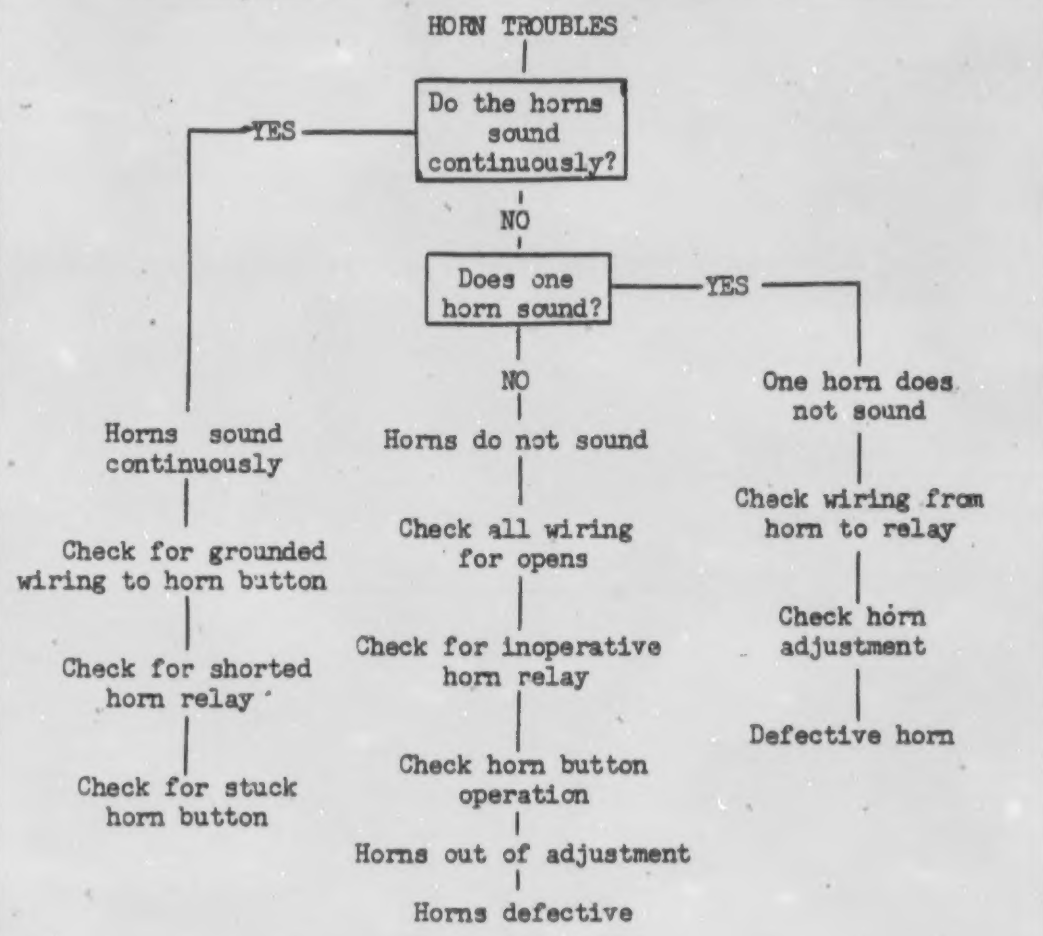
Defective Constant Voltage Regulator

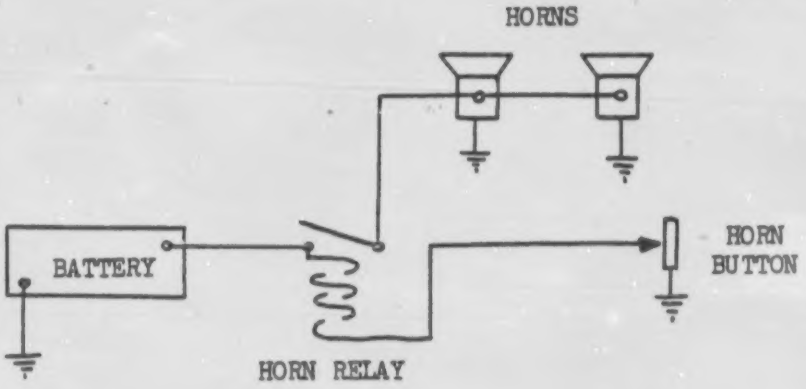
Defective Ignition Switch


IGNITION SWITCH
BATTERY
TO FUEL GAUGE
TO ENGINE TEMPERATURE GAUGE
CONSTANT VOLTAGE REGULATOR

TYPICAL CIRCUIT SCHEMATIC

Frame 8.


HORN TROUBLES
Do the horns sound continuously?
YES
NO
Does one horn sound?
YES
NO
Horns sound continuously
Check for grounded wiring to horn button
Check for shorted horn relay
Check for stuck horn button
Horns do not sound
Check all wiring for opens
Check for inoperative horn relay
Check horn button operation
Horns out of adjustment
Horns defective
One horn does not sound
Check wiring from horn to relay
Check horn adjustment
Defective horn


HORNS
BATTERY
HORN RELAY
HORN BUTTON

TYPICAL CIRCUIT SCHEMATIC

Frame 9.

Headlights Do Not Light

Check for Loose Battery Cable

Check Wiring from Battery
to Dimmer Switch

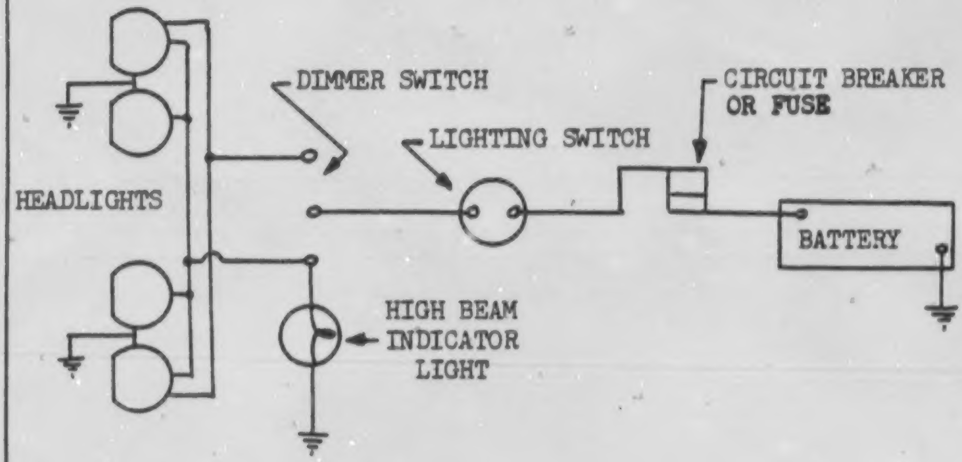
Defective dimmer switch*

Defective lighting switch

Defective circuit breaker or fuse

High voltage has
blown all lights

* If only the headlights fail to operate, the dimmer switch is the most probable cause.


DIMMER SWITCH
CIRCUIT BREAKER OR FUSE
LIGHTING SWITCH
HEADLIGHTS
BATTERY
HIGH BEAM INDICATOR LIGHT

TYPICAL CIRCUIT SCHEMATIC

Frame 10.

Individual Lights Do Not Light

Burned Out Bulb

Check loose/broken wiring to bulb

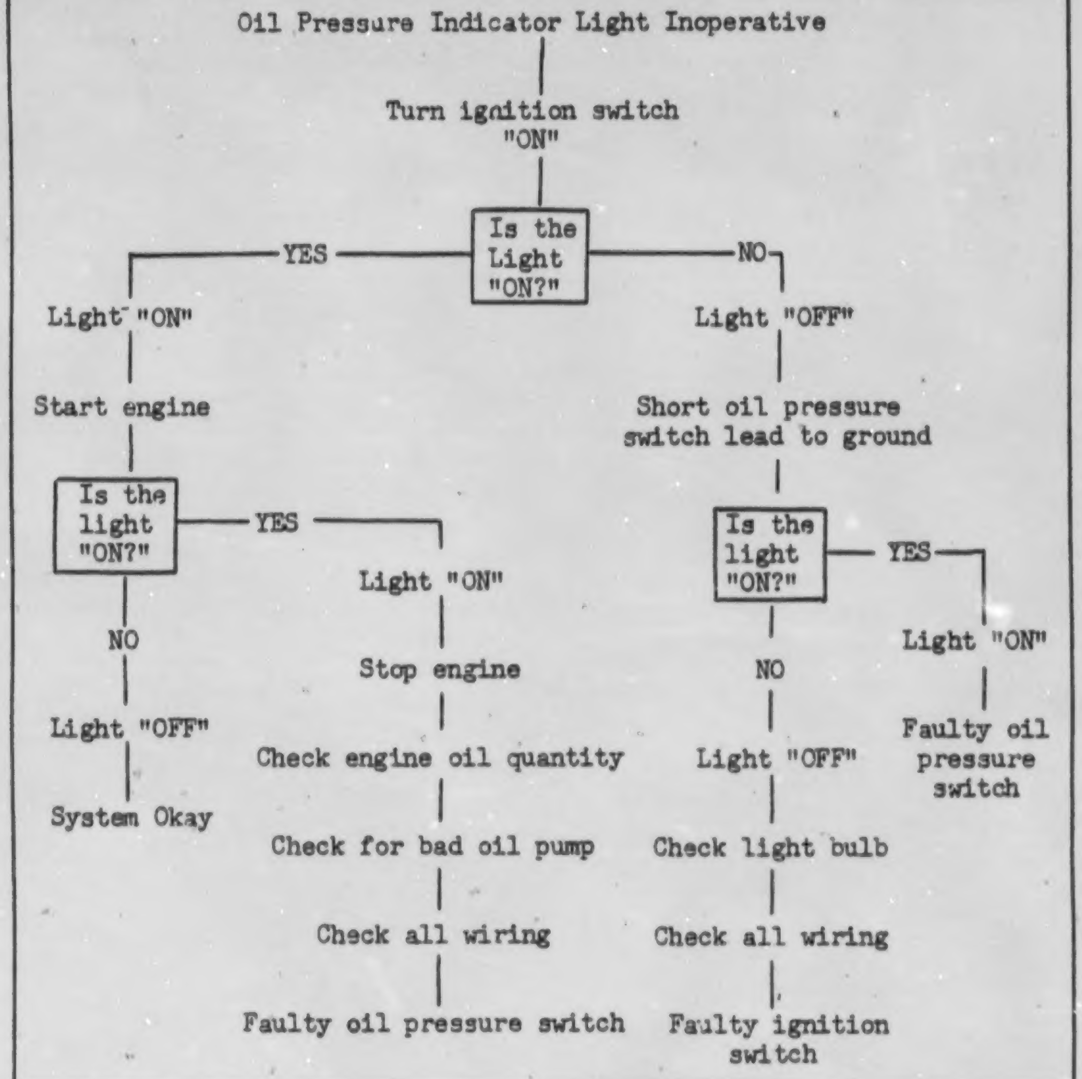
Check for poor ground connection

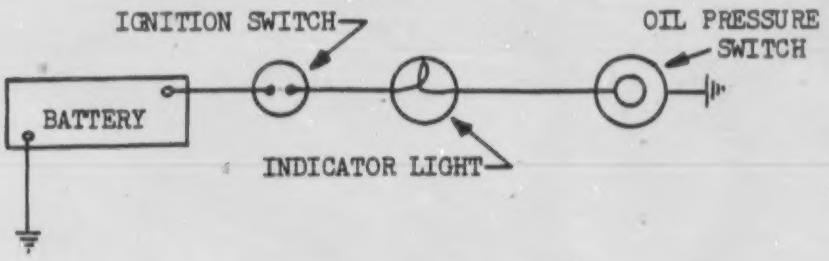
Lights Burn Out Repeatedly

Check for loose or corroded connections

Excessive vibration

Generator voltage regulator set too high


Oil Pressure Indicator Light Inoperative
Turn ignition switch "ON"
Is the Light "ON?"
YES
NO
Light "ON"
Start engine
Is the light "ON?"
YES
NO
Light "OFF"
System Okay
Light "ON"
Stop engine
Check engine oil quantity
Check for bad oil pump
Check all wiring
Faulty oil pressure switch
Light "OFF"
Short oil pressure switch lead to ground
Is the light "ON?"
YES
Light "ON"
Faulty oil pressure switch
NO
Light "OFF"
Check light bulb
Check all wiring
Faulty ignition switch


IGNITION SWITCH
OIL PRESSURE SWITCH
BATTERY
INDICATOR LIGHT

TYPICAL CIRCUIT SCHEMATIC

Frame 12.

Parking, Rear, Instrument or Dome Lights Inoperative

Check for burned out fuse

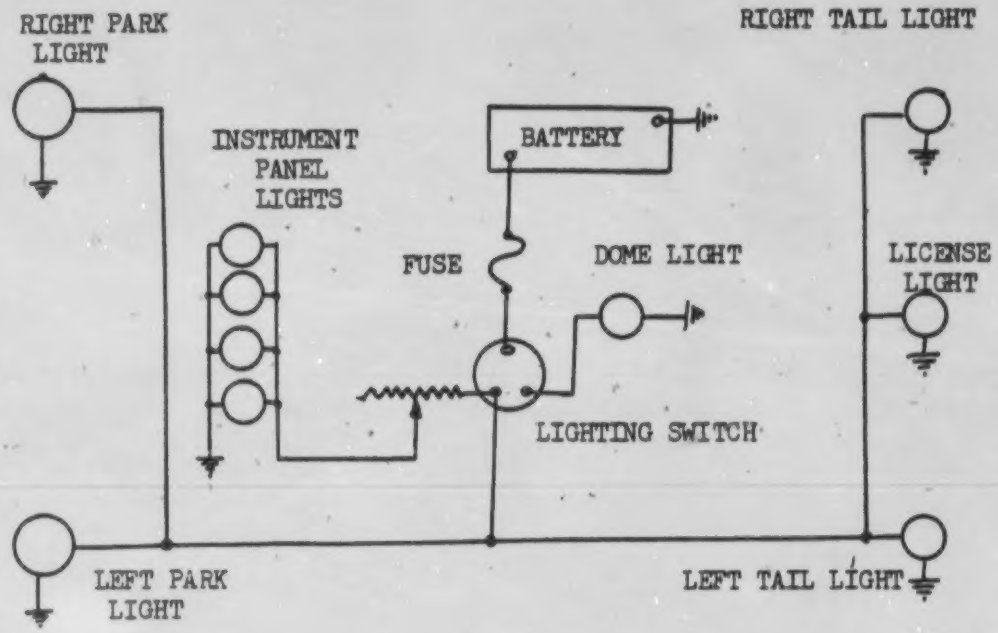
Check wiring from battery to light switch

Defective light switch

Check wiring from switch to lights

Check for burned out bulbs

Poor ground connections

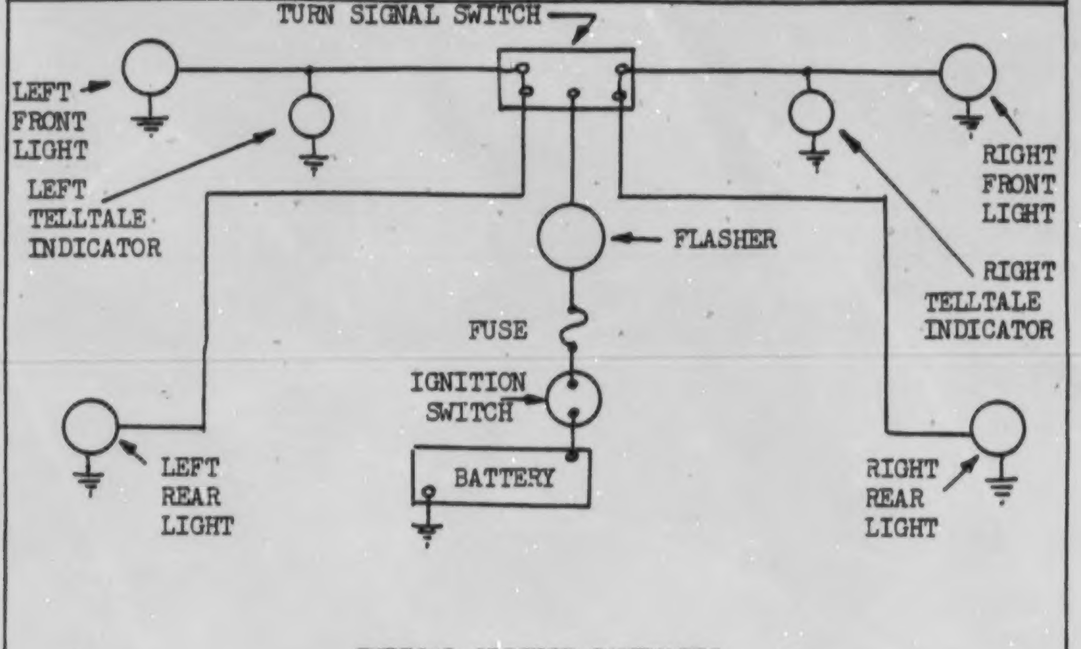

RIGHT PARK LIGHT
RIGHT TAIL LIGHT
INSTRUMENT PANEL LIGHTS
BATTERY
FUSE
DOME LIGHT
LICENSE LIGHT
LIGHTING SWITCH
LEFT PARK LIGHT
LEFT TAIL LIGHT

TYPICAL CIRCUIT SCHEMATIC

Turn Indicator Light Troubles

Do lights cancel improperly?

- YES → Lights cancel improperly
  - Check cam position on steering wheel hub.
  - Check for loose or weak coil springs on switch plate assembly
- NO → Are all lights inoperative?
  - NO → Lights operate incorrectly
    - Check wiring from switch to lights
    - Defective turn signal switch
    - Defective flasher
    - Check for burned out bulbs
  - YES → All lights are inoperative
    - Check for burned out fuse
    - Check wiring from ignition switch to flasher
    - Defective flasher
    - Check wiring from flasher to turn switch
    - Defective turn signal switch
    - Check wiring from switch to lights
    - Check for burned out bulbs
    - Poor ground connections


TURN SIGNAL SWITCH
LEFT FRONT LIGHT
LEFT TELLTALE INDICATOR
RIGHT FRONT LIGHT
RIGHT TELLTALE INDICATOR
FLASHER
FUSE
IGNITION SWITCH
BATTERY
LEFT REAR LIGHT
RIGHT REAR LIGHT

TYPICAL CIRCUIT SCHEMATIC

Vehicle Maintenance Branch
Chanute AFB, Illinois

3ABR47330-WS-404A

TROUBLESHOOTING, DIAGNOSIS, AND REPAIR OF LIGHTING, WARNING AND SIGNAL SYSTEMS AND HEADLIGHT TESTING (HEADLIGHT TESTER)

OBJECTIVES

Upon completion of this worksheet you will be able to:

Operate the headlight tester for showing the condition of headlights quickly and exactly, and perform the steps for making necessary adjustments.

EQUIPMENT

Vehicle
Headlight tester
Mechanics Handtools

PROCEDURE

Using the worksheet as a guide for step-by-step procedures, check condition of headlights and make the necessary adjustments.

1. Practice all safety precautions.

Note: Think safety - practice safety - act safely.

2. Obtain the technical order from the file and record number.

3. Calibrate tester to location.

a. Place tester in front of the vehicle with lens about 12 inches in front of the headlights and facing the vehicle.

b. Roll the tester sideways, parallel to the front of the vehicle, until it is clear of the vehicle.

c. Place the calibrating stand in front of the tester as shown in figure 13. Grasp the handles on the case support. Raise or lower the tester case until the white horizontal line that is on the side of the lens frame is at the exact same height as the white line scribed on the flat circular portion at one side of the calibrating stand top.

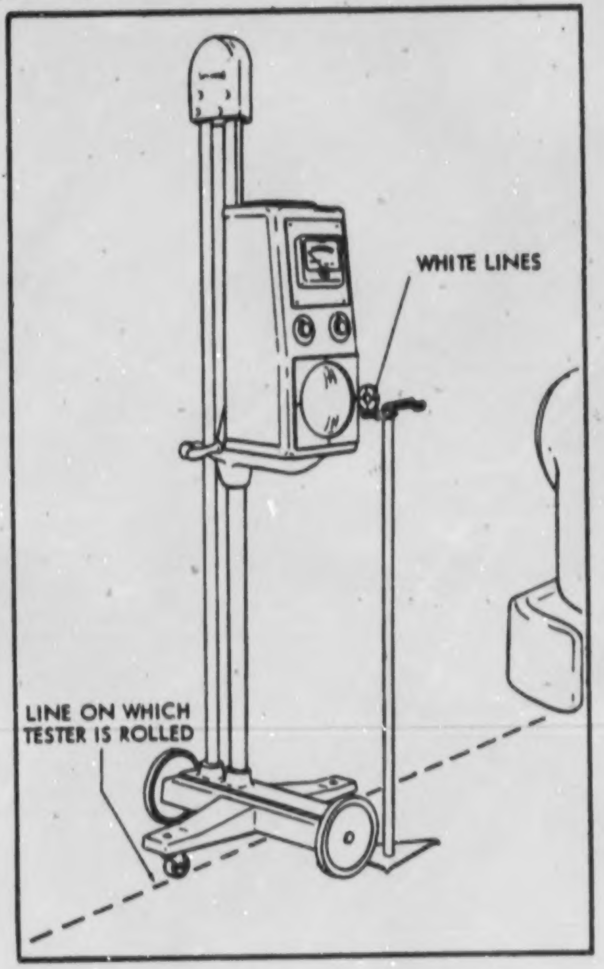


Figure 13. Setting Tester to Height of Calibrating Stand.

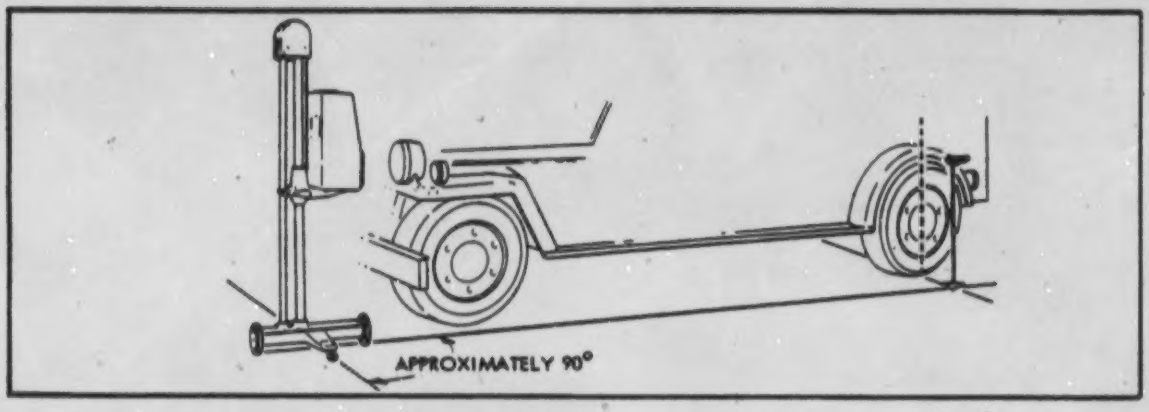

APPROXIMATELY 90°

Figure 14. Using Flashlight to Check Floor Level.

Note: Be careful not to move tester base.

d. Remove the calibrating stand to a position opposite the rear fender of the vehicle at about the same distance to the side of the vehicle as the tester, as shown in figure 14.

e. Place a lighted flashlight on the stand top so that the light shines through the hole in the part on which the white line is scribed. Point the flashlight beam directly at the center of the tester lens.

Note: You will see a small reflection of the flashlight beam in the tester lens. When this reflection is at maximum brightness, the beam will be pointed correctly.

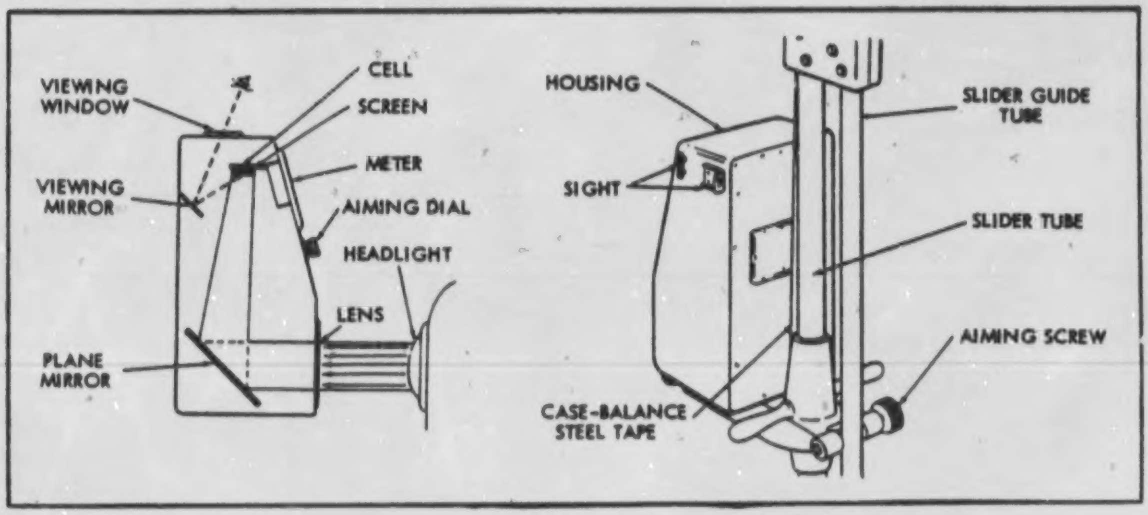

VIEWING WINDOW
CELL
SCREEN
METER
VIEWING MIRROR
AIMING DIAL
HEADLIGHT
LENS
PLANE MIRROR
HOUSING
SLIDER GUIDE TUBE
SIGHT
SLIDER TUBE
AIMING SCREW
CASE-BALANCE STEEL TAPE

Figure 15. Operating Parts of Tester.

f. Look down through the viewing window of the tester, figure 15, at the image of the flashlight beam as seen in the viewing mirror, figure 16. Turn the high-low and/or left-right knobs, figure 17, at the front of the tester until this beam image is well centered in the large circle also seen in the mirror.

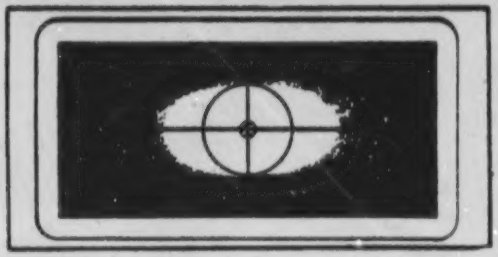


Figure 16. Centering Beam Reflection Inside Tester.

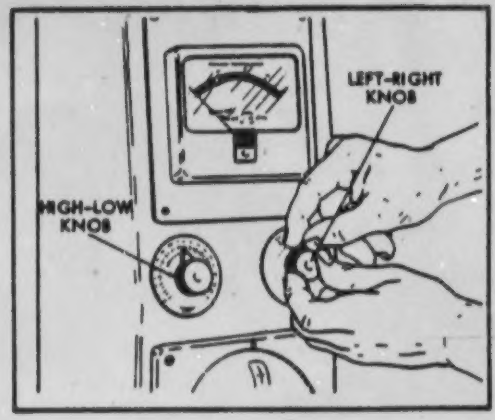


Figure 17. Resetting High-Low Tester Knob.

g. After centering the image, grasp the high-low knob firmly in one hand and, without turning the knob, turn the pointer to place it at "0" on the dial, figure 17. Recheck to make sure that the beam image is still properly centered.

Note: Be careful not to disturb the left-right knob, or the position of the tester while making this adjustment. When the adjustment is made, the fore-to-aft axis of the plane mirror, figure 15, is lined up with the plane of the floor on which the vehicle stands during a following headlight test.

4. Prepare vehicle for test.

a. Clean headlight lens.

b. Adjust headlight reflector.

Note: The reflectors must be in working order so that they can be pivoted up or down, or to either side as required to correct the beam directions.

c. Check the switch used to change the headlights from high beam to low beam. Make certain that both headlights work at the same time.

Note: Note that sometimes the wires become interchanged so that one beam is high while the other is low.

d. Check vehicle to see that it is unloaded.

e. Inflate tires to specified pressures

f. Rock vehicle sideways to relieve any spring set and make certain that the vehicle stands in a normal position.

5. Use headlight tester to test headlights.

a. Square tester with vehicle, figure 18.

(1) Roll the tester from in front of one headlight to in front of the other to make certain that it travels a straight line parallel to the front of the vehicle.

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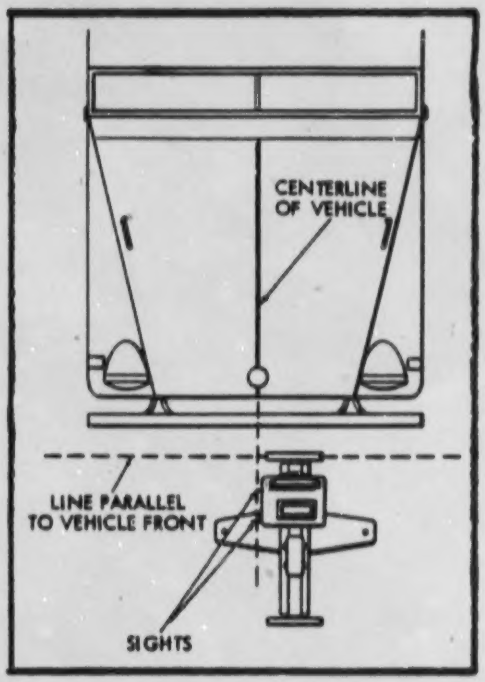

Figure 18. Aligning Tester With Vehicle Centerline.

Note: The tester should be about 12 inches out from the headlights.

(2) Find the fore-to-aft centerline of the vehicle.

Note: This can be done by visualizing an imaginary line through the center of the radiator cap or ornament, backward along the center of the hood and center of the windshield.

(3) Roll the tester along the parallel front line to line up the peep slot in the back part of the sight with the vehicle centerline.

Note: The peep slot in the back part of the sight is at the left side of tester case.

(4) Rotate the aiming screw, figure 15, to place the line formed by the front part of the sight on the centerline, so that the centerline is straight through both parts of the sight.

Note: Once made, this adjustment must remain unchanged throughout a test.

b. Test either headlight.

(1) Turn the headlights on the high beam.

(2) Roll the tester sideways along the parallel front line to place the tester lens directly in front of the headlight being tested.

(3) Raise or lower the tester case until the meter indicates maximum candlepower.

Note: Be careful not to move the base.

(4) Roll tester to one side or the other until the meter again indicates the maximum candlepower.

(5) Continue steps (3) and (4) until you are certain you have obtained exact position of tester candlepower as indicated.

Note: Be careful not to move the tester base off the parallel line. The tester lens is now squarely in front of the headlight. The tester case must not be moved from this position during the remainder of the test.

(6) Operate the high-low and left-right knobs, figure 17, until the meter indicates maximum candlepower.

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Note: The plane mirror, figure 15, is now in perfect alignment with the headlight beam. Test results may be read on the meter and calibrated dials at the front of the tester case.

c. Interpret results of test.

Note: The maximum brightness of the headlight can be read on the meter with the tester in the final position. Reading is in thousands of candlepower. Divisions marked on the dial show "POOR," "GOOD," mnd "EXCELLENT" ranges. At the end of test, the calibrated dials of the high-low and left-right knobs will show the beam direction. These are graduated to show the number of inches that the beam will drop, raise, or turn to one side at a distance of 25 feet in front of the vehicle.

d. Correct misdirected beam, if required.

Note: The usual drop is three inches in 25 feet (shown by the arrow on the high-low knob dial between the "2" and "4" at the right of the "0"). Some operators prefer no side angle (left-right knob set at "0"). Others prefer to have the right headlight set in this manner, but to have the left headlight slightly toed in (knob set at "2" to "4" to the right of "0" on the dial).

(1) Set the high-low and left-right knobs, figure 17, to show the amount of drop and side angle desired.

(2) Adjust the headlight reflector until a maximum candlepower reading is shown on the tester meter, if required.

Note: The tester must not be moved from its last position in the test when making this adjustment.

Vehicle Maintenance Branch
Chanute AFB, Illinois

3ABR47330-WS-404B

TROUBLESHOOTING, DIAGNOSIS, AND REPAIR OF LIGHTING, WARNING AND SIGNAL SYSTEMS AND HEADLIGHT TESTING (AC HEADLIGHT AIMER)

OBJECTIVES

Upon completion of this worksheet you will be able to:

Operate the headlight aimer for showing the condition of headlights quickly and exactly, and perform the steps for making the necessary adjustments.

EQUIPMENT

Vehicle
Headlight
Mechanics handtool

PROCEDURE

Using the worksheet as a guide for step-by-step procedures, check condition of headlights and make the necessary adjustments.

AIMING THE HEADLIGHTS

Preaiming Instruction.

1. Check dimmer switch for faulty operation.

2. Check high beam indicator-indicates the HIGH beam is in operation when lighted.

3. Check for badly rusted or faulty headlamp assemblies. These must be corrected before a satisfactory adjustment can be made.

4. Place vehicle on a level floor.

5. Check front suspension height. Adjust to specifications as necessary.

6. Check tire inflation.

7. Rock vehicle sideways to allow vehicle to assume its normal position.

8. If gasoline tank is not full, place a weight in the trunk of vehicle to simulate the weight of a full tank (6-1/4 pounds per gallon).

9. There should be no other load in the vehicle other than the driver or a substituted weight of approximately 150 pounds placed in the driver's position.

10. Remove headlamp front trim panel. Do not remove the seal beam retainer rims.

Checking Aimer for Calibration.

1. Using a carpenter or stone mason level of known accuracy, locate a true vertical plate glass window or smooth surface.

2. Set DOWN-UP pointer on DOWN 2.

3. Set RIGHT-UP pointer and floor level compensator at "0."

4. Secure aimers to glass or smooth surface three to five feet apart so split image targets can be located in the viewing port.

5. If bubble is centered in glass vial, vertical calibration is correct. If bubble is not centered, make the DOWN-UP adjustment by rotating the level adjusting screw until the bubble is centered in the spirit level.

6. The horizontal aim is correct if the targets on opposite aimers are aligned in viewing ports. If targets are not aligned in viewing ports, rotate mirror adjusting screw until target split image becomes aligned.

Compensating and Mounting the Aimer.

1. For mechanical aim, the slope of the floor should be known.

2. Place transit on floor in line with vertical centerline of the right front wheel. Place split image target in like position at right rear wheel.

3. Adjust range screw on transit until target split image coincides or merges into one unbroken line.

Note: Make sure that line of sight is perpendicular from the eye to the viewing port of the transit image centered in viewing port of transit.

4. Turn dial on side of transit until bubble in spirit level is centered.

5. When bubble is centered, note "plus" or "minus" reading on compensator scale. This figure indicates the degree of slope of the floor and must be transferred to each aimer.

6. With a screwdriver, turn adjusting slot of floor level compensator in each aimer, until the correct plus or minus figure (or fractional part appears in the proper window).

Mounting and Adjusting the Aimers

1. While holding an aimer in alignment with the lens of one OUTBOARD headlamp, bring aimer up to and against headlamp lens.

Note: Make certain that the headlamp lens pads are making full contact with the aimer mounting flange and that the aimer target is facing inboard.

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2. Push the release lever forward (to expel air from suction cup) and while holding the aimer firmly against the headlight aiming pads, slowly pull the release lever back until the spring lock engages in the slot.

3. Mount the second aimer on the other outboard headlamp, in the same manner.

4. On each aimer, set pointer to numeral 2 on the DOWN side of the DOWN-UP scale.

5. On each aimer position the pointer, of the RIGHT-LEFT scale, at 2-RIGHT.

CHECKING HEADLIGHT AIM

Horizontal Check

1. Turn the RIGHT-LEFT scale knob until the split image is in alignment. If the RIGHT or LEFT portion of scale exceeds the following values, the lamps should be aimed. Values given represent inches at 25 feet.

	RIGHT	LEFT
#1 UNIT	4	4
#2 UNIT	4	0

Vertical Check

1. Turn DOWN-UP scale knob until the spirit level is centered. If DOWN or UP portion of the scale exceeds the following values, the lamps should be aimed.

	DOWN	UP
#1 UNIT	1/2 to 3-1/2	0
#2 UNIT	1/2 to 3-1/2	0

ADJUSTING THE HEADLAMPS

Horizontal Adjustment

1. With the pointer of RIGHT-LEFT scale still set at 2-RIGHT, sight through the aimer viewing port. MAKE SURE THAT THE LINE OF SIGHT IS PERPENDICULAR FROM THE EYE TO THE VIEWING PORT OF THE AIMER AND THAT THE TARGET IMAGE IS CENTERED IN THE VIEWING PORT OF THE AIMER.

2. While sighting through the viewing port of the aimer, turn the horizontal adjusting screw on the headlamp until the split image target line merges into one unbroken line. TO REMOVE BACKLASH, BE SURE TO MAKE A FINAL ADJUSTMENT BY TURNING HEADLAMP HORIZONTAL ADJUSTING SCREW IN A CLOCKWISE DIRECTION.

3. Make the horizontal adjustment on the other OUTBOARD headlamp in the same manner.

Vertical Adjustment

1. Turn vertical adjusting screw on headlamp in a counterclockwise direction to bring the bubble of the spirit level on the aimer to car side of center. Use care to avoid disturbing the installed position of the aimers. Then turn the screw clockwise until the bubble is centered for correct aim and elimination of backlash.

2. Make the vertical adjustment on the other OUTBOARD unit in the same manner.

3. Recheck the target alignment on each side and readjust the horizontal aim, if necessary. Proceed to adjust the inboard units by following the instructions as outlined for the outboard headlamps. Install headlamp trim panels.

> Note: Remove the aimers by releasing the spring lock at the rear (bottom) of the aimer and pushing the release lever forward. Do not attempt to remove the aimers by pulling them away from the headlamp lens. Slide the suction cup downward and away from the lens.

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General Vehicle Maintenance Branch
Chanute AFB, Illinois

3AZR47252-1-HO-206
3ABR47232-HO-403
15 October 1975

AIR SYSTEM DIAGNOSIS

The air system will limit exhaust emission to a level below requirements if it is properly installed and maintained; but, will not provide the desired reduction in exhaust emissions if some of the engine components malfunction.

Because of the relationship between engine tune-up and unburned exhaust gases, the condition of the engine should be checked whenever the air system seems to be malfunctioning. Particular care should be taken in checking items that affect the fuel-air ratio, such as the crankcase ventilation system, the carburetor, and the carburetor air cleaner.

If all other components seem to be operating satisfactorily, visually inspect the air system as previously explained.

If malfunction persists after completion of tune-up and visual inspection, refer to the following diagnosis chart for symptoms, probable cause, and remedy.

Note: Use this handout in support of 3AZR47350-1-SG-205, for recommended solutions to malfunctions.

Because of energy conservation, the vehicles and/or engines will be operated only long enough to accomplish the given malfunctions.

TROUBLE	PROBABLE CAUSE	REMEDY
1. PUMP NOISY	Before trying to isolate the cause, it should be noted that the air system is not completely noiseless. Under normal conditions, noise rises in amplitude as engine speed increases. Air pump noise can be confused with other engine noises.	
	Hose disconnected or leaking.	Reconnect or replace.
	Overly torqued pivot bolt.	Torque to 15-20 feet-pounds.
	Faulty relief valve (if mounted in pump).	Replace valve.

Supersedes 3AZR47350-1-HO-206, 8 May 1974.
OPR: TWS
DISTRIBUTION: X
TWS - 300; TTVGC - 3

Designed for ATC Course Use. Do Not Use on the Job.

TROUBLE	PROBABLE CAUSE	REMEDY
	A "chirping" noise may be prevalent on new pump.	Allow break-in time.
	A continuous "knocking" noise is indicative of rear bearing failure.	Replace pump.
	Improper belt tension.	Readjust.
	Seized or binding pump.	Replace.
	Incorrect or missing pressure setting plug (if relief valve is mounted on pump).	Replace plug.
	Bent or misaligned pulleys.	Inspect belt alignment, replace pulleys.
2. POPPING IN EXHAUST SYSTEM: HOT IDLE	Sound similar to muffler hitting floor pan. Caused by rich idle mixture.	Adjust idle mixture screws, use Specification Manual.
COLD IDLE (CHOKE ON)	Same as above. Moderate popping is inherent design characteristic of system when cold.	Same as above. Also inspect choke and vacuum break operation and settings. On manual choke models, instruct operator on proper operation.
ACCELERATION	Popping appears under load from idle. Popping noise level varies with timing (decreases with advance of timing) and carb, accelerator pump short duration.	Check ignition spark timing.* Check accelerator pump adjustment.

TROUBLE	PROBABLE CAUSE	REMEDY
3. BACKFIRE IN EXHAUST SYSTEM	Rich fuel mixture caused by: inoperative choke, misadjusted or sticking closed.	Inspect choke operation, correct as necessary.
	Inoperative vacuum break.	Replace vacuum break.
	Use of manual choke: generally overchoking.	Closer control of choking period.
	Air cleaner element restricted.	Replace element.
	Improper crankcase vent maintenance.	Inspect system. Replace PCV valve. Check fitting at carburetor; may be plugged with crankcase deposits. Check PCV filter. Replace if dirty.
	High fuel level.	Adjust float level.
	Diverter valve stuck in open position.	Check valve. Replace if defective.
	Diverter valve and distributor timing vacuum lines switched.	Correct hose routing.
4. BACKFIRE OR POPPING IN INLET MANIFOLD	Leaking inlet manifold.	Check manifold bolts for tightness.
	Incorrect ignition timing.	Check timing and set to specs.*

141c.

TROUBLE	PROBABLE CAUSE	REMEDY
5. OFF IDLE HESITATION AND ROUGH IDLE (HOT)	Appears in acceleration period from standing start to approximately 900 rpm and result from the following:	
	Vacuum leak - more noticeable on hot engine. This results from unconnected, split, or oversized hoses, or from hot idle compensator not closing, or opening prematurely. Can also be caused by a leaking carburetor or intake manifold gasket.	Inspect hoses, gaskets, and fittings for leaks. Close carburetor hot idle compensator. If this corrects conditions, replace hot idle compensator.
	A third cause can be insufficient fuel shot from carburetor accelerator pump or fuel leaking past seal during pump travel. (This does not apply to diaphragm type accelerator pumps.)	Check accelerator pump adjustment. If rubber seal is hard, or falls into cavity by its own weight (with return spring removed), it should be replaced. There should be slight interference between cup and wall.
	Carburetor float level low.	Adjust as required.
	Initial timing out of specification.	Check initial setting to specifications.*
6. ROUGH IDLE OR SURGE	Improper carburetor adjustment, idle fuel mixture, choke, etc.	Check carburetion and adjust as necessary.*
	Improper ignition timing.	Set timing to specs.*
	Vacuum leak at signal line to diverter valve or distributor, vacuum leak at carburetor or intake manifold.	Inspect and correct lines and connections. Check for leaks at carburetor and intake manifold gaskets.

141 d.

TROUBLE	PROBABLE CAUSE	REMEDY
7. ENGINE IDLE SPEED HIGH	Throttle linkage sticking or obstructed by hoses.	Inspect linkage and eliminate points of interference.
	Idle speed set incorrectly.	Reset idle speed to specs.*
8. ENGINE "DIESELS" AFTER IGNITION IS TURNED OFF	Idle speed to high.	Reset idle to specs.*
	Solenoid (on units so equipped) stuck in "UP" position.	Free-up or replace solenoid.
	Low octane fuel.	Use higher octane fuel or premium.
9. OVERHEATED EXHAUST SYSTEM	Ignition timing retarded, excessive burning in exhaust system.	Reset timing to specs.*
	Incorrect or missing pressure relief valve plug in air pump.	Check for correct plug. Install if missing.
10. CHARGED DETERIORATED SUPPLY HOSE	Defective check valves.	Replace check valves.
11. CONSTANT AIR NOISE	Broken hose.	Replace hose.
	Diverter valve stuck closed.	Replace diverter valve.

* Refer to Specification Manual.

Caution: Because the air pump air filter provides a direct path into the pump, cover the filter whenever cleaning the engine.

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PREPARE THE MAN

PROGRAMMED TEXT 3ABR47~~330~~232-PT-403

8-11

Technical Training

Automotive ~~Repairman~~ Mechanic

CLAYTON CHASSIS DYNAMOMETER

1 June 1970

CHANUTE TECHNICAL TRAINING CENTER (ATC)

OPR: TSDT
DISTRIBUTION: X
TSDT - 500; TSOC - 2

Designed For ATC Course Use

FOREWORD

This programmed text was prepared by personnel of the ISD team for use in the 3ABR47330 Automotive Repairman Course. It was validated with target population students in 1964. The text has been successfully used by 1040 students in the course.

OBJECTIVES

1. Upon completion of part one of this programmed text, you will be able to select statements that identify the purpose, component locations and component functions of the Clayton chassis dynamometer.

2. Given the necessary handtools, a dynamometer and part II of this programmed text, you will be able to:

    a. Start and operate the Clayton Chassis Dynamometer.

    b. Record readings taken from the dynamometer indicators.

    c. Adjust the engine performance according to text information.

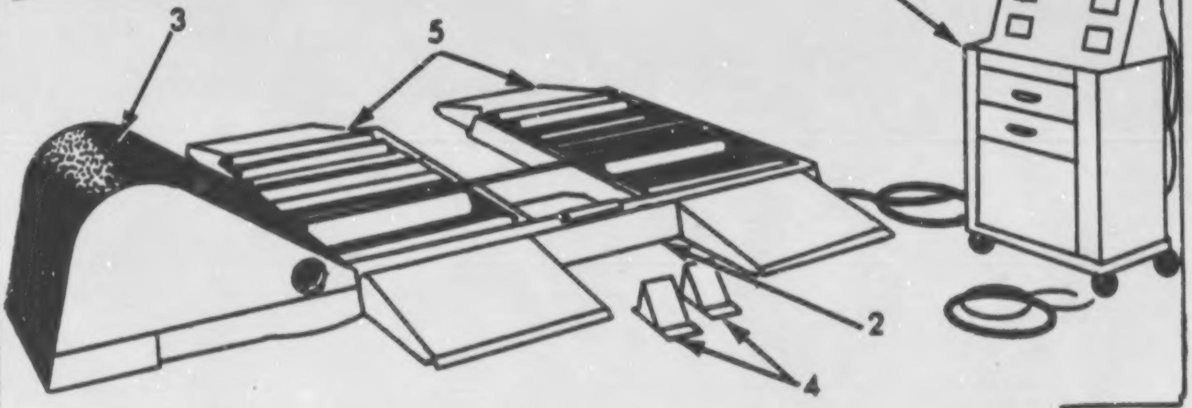
3. Using the information gained in parts one and two and given hypothetical dynamometer test results you will be able to analyze and select the probable cause of engine malfunctions.

90% accuracy is required for this program.

INSTRUCTIONS

This programmed text is written in segments called frames. Each frame contains a bit of information and is followed by one or more questions. Read each frame and respond to the question for that frame. Before going to the next frame check your answer with the ones in frame 50, which is your confirmation frame.

Frame 1.



The diagram above is that of a Clayton Chassis Dynamometer. Study this diagram for a few moments to acquaint yourself with the different components. Notice that the dynamometer consists of an instrument cabinet (1), dynamometer chassis (2), flywheel cover (3), wheel chocks (4), and bogie roll units (5).

The instrument and cooler cabinet contains an auxiliary cooling system, power meter, speed meter, tachometer, cam angle (dwell) meter, vacuum gauge, exhaust gas analyzer (combustion meter), and various controls for these and other related components.

The dynamometer chassis contains the drive rollers, idle rollers, power absorption unit, torque bridge, flywheel, heat exchanger, and various other connected or related components.

The instrument and cooler cabinet is connected to the dynamometer chassis by a group of wires and hoses.

Frame 2.

The chassis dynamometer puts the vehicle to work exactly as it works on the road and the unit continuously measures the vehicle's ability to work.

QUESTION 1.

? ?

? Which of the following statements best describes the purpose of the chassis dynamometer? ?

?

a. To use up the power produced by a vehicle. ?

? b. To absorb and measure road horsepower. ?

? c. To use up space in the automotive shop. ?

d. To provide jobs for other mechanics.

? ?

? ?

The vehicle produces power which is transferred through the rear wheels and the drive roller to the power absorption unit. The power absorption unit absorbs the power and sends a signal through a lever to the torque bridge. The torque bridge is adjusted by the signal from the power absorption unit and sends an electrical signal to the power meter in the instrument cabinet.

QUESTION 2.

? ?

Which of these statements is false?

a. The drive roller produces the power indicated on the power meter.

b. The torque bridge sends a signal to the power meter.

c. The power meter indicates the horsepower being produced by the vehicle.

d. The power absorption unit uses up the power being produced by the vehicle.

e. The drive roller is not connected directly to the torque bridge.

? ?

QUESTION 3.

? ?

According to the information in Frame 2, which of the following statements is false?

a. The drive roller transfers power from the rear wheels to the power absorption unit.

b. The power absorption unit absorbs the power being produced by the torque bridge.

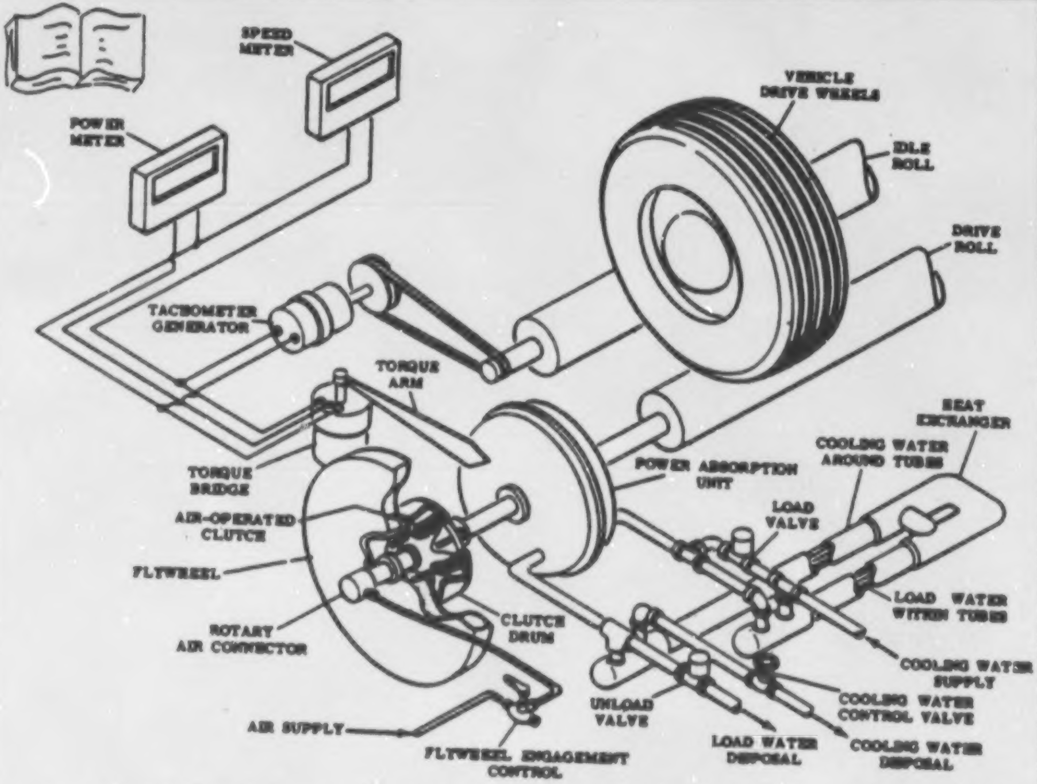
c. The amount of power being absorbed is not adjusted by the torque bridge.

d. The power absorption unit sends a signal to the torque bridge.

? ?

Seems a little confusing doesn't it? Really, it isn't. Just think about it for a moment. The dynamometer is reproducing only actual vehicle actions. How many times have you thought, "If I could only diagnose this vehicles trouble while it is traveling 60 miles per hour I could determine the exact problem"? So, just think of the dynamometer as the highways you normally drive on and perhaps this will make the lesson a little clearer to you.

Frame 4.

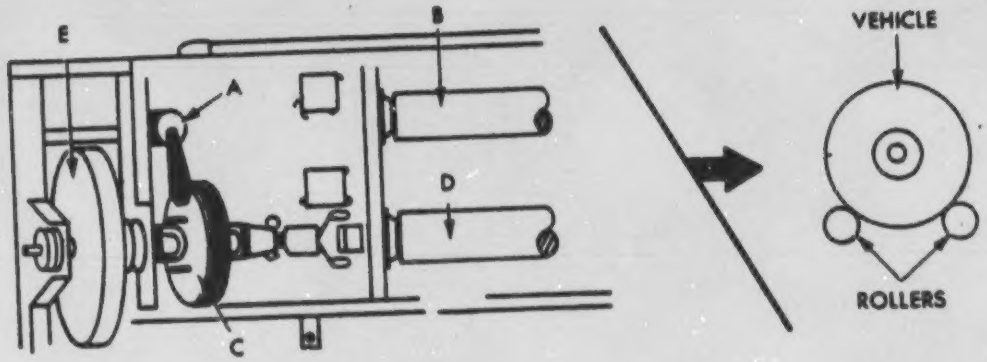

SPEED METER
POWER METER
VEHICLE DRIVE WHEELS
IDLE ROLL
DRIVE ROLL
TACHOMETER GENERATOR
TORQUE ARM
HEAT EXCHANGER
COOLING WATER AROUND TUBES
TORQUE BRIDGE
POWER ABSORPTION UNIT
LOAD VALVE
AIR-OPERATED CLUTCH
FLYWHEEL
LOAD WATER WITHIN TUBES
ROTARY AIR CONNECTOR
CLUTCH DRUM
COOLING WATER SUPPLY
COOLING WATER CONTROL VALVE
UNLOAD VALVE
AIR SUPPLY
LOAD WATER DISPOSAL
COOLING WATER DISPOSAL
FLYWHEEL ENGAGEMENT CONTROL

The vehicle wheels are positioned on and between the rollers when the vehicle is on the chassis dynamometer, see figure above.

One roller is the idle roller and the other is the drive roller. The drive roller is connected to the power absorption unit by a short propeller shaft.

The power absorption unit is connected to a shaft sticking out of the top of the torque bridge.

The flywheel is connected to the power absorption unit by a shaft and an air-operated clutch.



QUESTIONS 4 through 7

? ?

4. In the diagram above, which arrow is pointing to the idle roller? Blacken the appropriate space (a, b, c, d, or e) on your answer sheet.

5. Using the diagram above, select the correct statement.

   a. The flywheel is labeled "E".

   b. The torque bridge is labeled "B".

   c. The idle roller is labeled "A".

   d. The power absorption unit is labeled "D".

6. Using the diagram above, select the correct statement.

   a. The torque bridge is connected to the drive roller and is labeled "E".

   b. The torque bridge is connected to the power absorption unit and is labeled "A".

   c. The torque bridge is connected to the flywheel and is labeled "D".

7. Using the diagram above, select the correct statement.

   a. The drive roller is connected to a short propeller shaft and is labeled "A".

   b. The drive roller turns the power absorption unit and is labeled "D".

   c. The drive roller is located between the power absorption unit and the flywheel and is labeled "E".

? ?

Frame 6.

QUESTION 8.

? ?

? Using the figure in the previous frame, select the correct statement.

? a. The power absorption unit is controlled by the idle roller and is labeled "B". ?

? b. The power absorption unit is controlled by the flywheel and is labeled "E". ?

? ?

? c. The power absorption unit is driven by the drive roller and is labeled "C". ?

? ?

The purpose of the entire chassis dynamometer is to duplicate the vehicle's action by absorbing and measuring road horsepower. Before the dynamometer can duplicate the action of the vehicle, the power of the vehicle must be transferred to the power absorption unit by the drive roller.

QUESTIONS 9 and 10.

? ?

? 9. Absorbing and measuring the road horsepower is the function of the ?

? a. drive roller. ?

? b. power absorption unit. ?

? c. torque bridge. ?

? d. chassis dynamometer. ?

? 10. Which of the following units delivers power from the rear wheels to the power absorption unit? ?

? ?

? a. Drive roller. ?

? b. Torque bridge. ?

? c. Chassis dynamometer. ?

? d. Power meter. ?

? ?

When the power produced by the vehicle is used up by the power absorption unit, the torque bridge receives a signal from the power absorption unit and relays this signal to the power meter. When this is done, a horsepower reading can be taken from the power meter.

QUESTIONS 11 through 13.

? ?

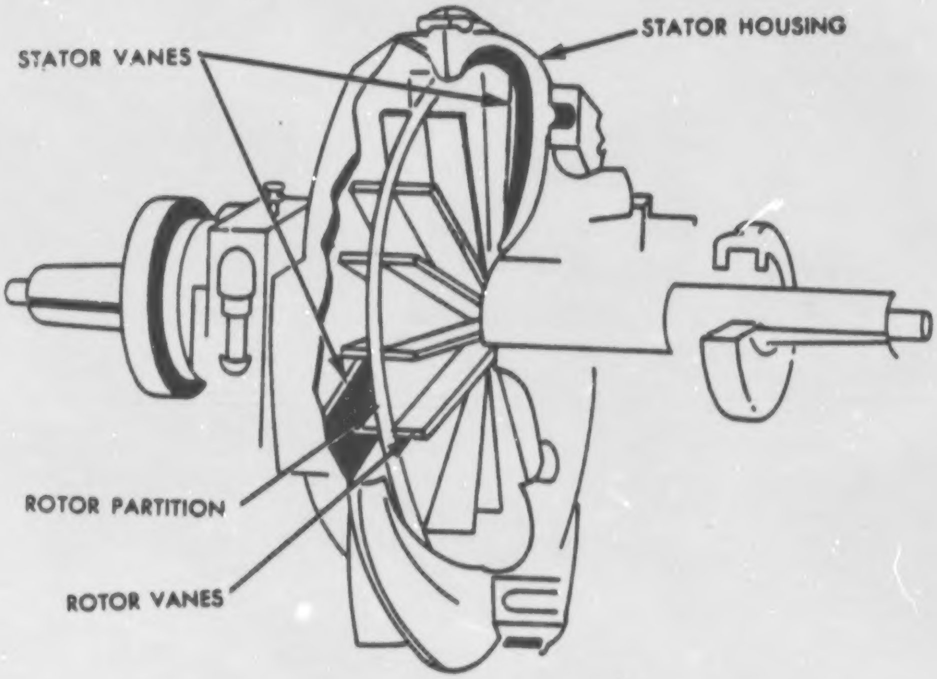
11. Which of these units use up power produced by the vehicle?
    - a. Torque bridge.
    - b. Drive roller.
    - c. Chassis dynamometer.
    - d. Power absorption unit.

12. Which of these units is responsible for receiving a signal from the power absorption unit and transferring it to the power meter?
    - a. Power meter.
    - b. Torque bridge.
    - c. Drive roller.
    - d. Power absorption unit.

13. Which of the following components is responsible for indicating vehicle road horsepower?
    - a. Power absorption unit.
    - b. Power meter.
    - c. Torque bridge.
    - d. Drive roller.

? ?

Frame 8.


STATOR HOUSING
STATOR VANES
ROTOR PARTITION
ROTOR VANES

The power absorption unit (shown in the drawing above) is similar to a centrifugal pump having vanes or blades on the rotor to throw the water outward. Unlike a pump, however, the outside housing or stator also has vanes which oppose the flow of water and make the unit act as a water brake.

QUESTION 14.

? ?

? A power absorption unit acts like which of the following units? ?

? a. Water brake. ?

? b. Pump. ?

? c. Air brake. ?

? ?

Frame 9.

By maintaining a constant amount of water in the power absorption unit the load can be held indefinitely. By adding or releasing water the load can be changed. Water is added or released from the power absorption unit through the use of a remote load control switch which is controlled by the vehicle operator. To keep the water temperature low (friction in the power absorption unit will heat the water) a heat exchanger is built in the chassis of the dynamometer. That is, the water is circulated from the power absorption unit to the heat exchanger and back to the power absorption unit where it is used again.

The valve that operates the flywheel engagement unit is controlled by air pressure. Although the flywheel will not be used during this lesson, it is wise for you to know how it is operated.

QUESTION 15.

? ?

? How is the flywheel engaged? ?

? a. By a water-operated control valve. ?

b. By an air-operated control valve.

? c. By a manually-operated control valve. ?

? ?

On the end of the drive roller, opposite the power absorption unit is located a drive roller brake pawl. When this pawl is engaged, the operator is free to drive the vehicle on or off the rollers.

Frame 10.

QUESTION 16.

? ?

What is the purpose of the drive roller brake pawl?

a. To keep the drive roller from ever turning.

b. To keep the drive roller from turning only while a vehicle is being driven on the drive roller.

c. To keep the drive roller from turning only while a vehicle is being driven off the dynamometer.

d. To keep the drive roller from turning when a vehicle is being driven onto or off of the dynamometer.

? ?

As water is being used in the power absorption unit, friction is heating it. To prevent the water from overheating, it is forced through a pipe, which is surrounded by another pipe containing cold water, and then transferred back to the power absorption unit. This heat exchanger is located on the dynamometer chassis along the frame that supports the rollers.

QUESTION 17.

? ?

What unit of the chassis dynamometer is responsible for cooling the water used in the power absorption unit?

a. Power absorption unit.

b. Two pipes of cold water.

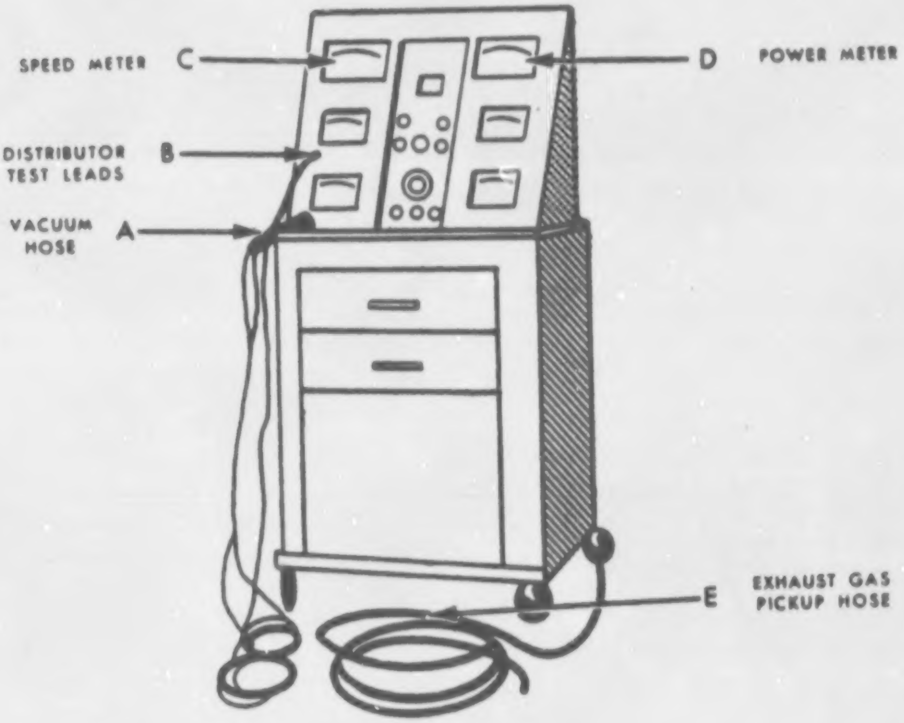
c. Heat exchanger.

d. The dynamometer chassis.

? ?

Frame 11.

The next few frames will be a little different from the last series that you have just completed. You will now see a picture with several components named. Your job will be to identify these components by reading a description of their function.


SPEED METER C
D POWER METER
DISTRIBUTOR TEST LEADS B
VACUUM HOSE A
E EXHAUST GAS PICKUP HOSE

QUESTIONS 18 and 19.

? ?

? Use the drawing above to aid in answering the questions. Blacken the appropriate space on your answer sheet. ?

? ?

18. Provides a connection to the intake manifold of the engine to sense manifold vacuum.

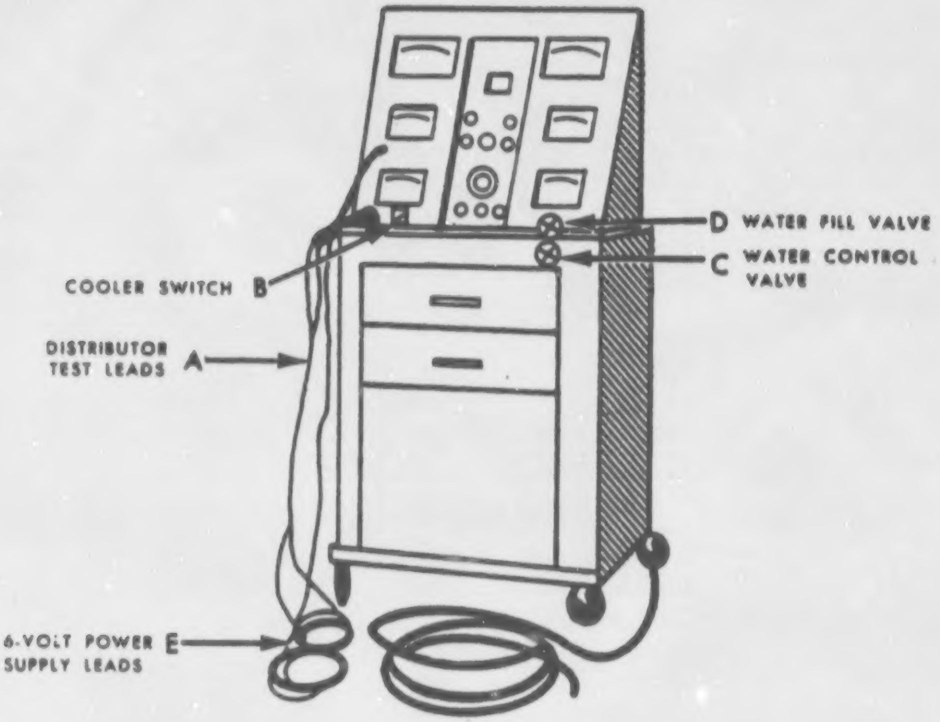
? ?

19. Provides a connection to the vehicle tailpipe to sense the quality of the exhaust gas.

? ?

? ?

Frame 12.


D WATER FILL VALVE
C WATER CONTROL VALVE
COOLER SWITCH B
DISTRIBUTOR TEST LEADS A
6-VOLT POWER SUPPLY LEADS E

QUESTIONS 20 through 24.

? ?

Using the drawing above, blacken the appropriate letter on your answer sheet (a, b, c, d, or e for each question) which matches the component in the drawing to the description below.

20. Provides a way to fill the vehicle radiator (if needed).

21. Provides a connection to the vehicle ignition system to sense cam angle and engine RPM.

22. Provides a means of switching the vehicle auxiliary pump (cooler) on or off.

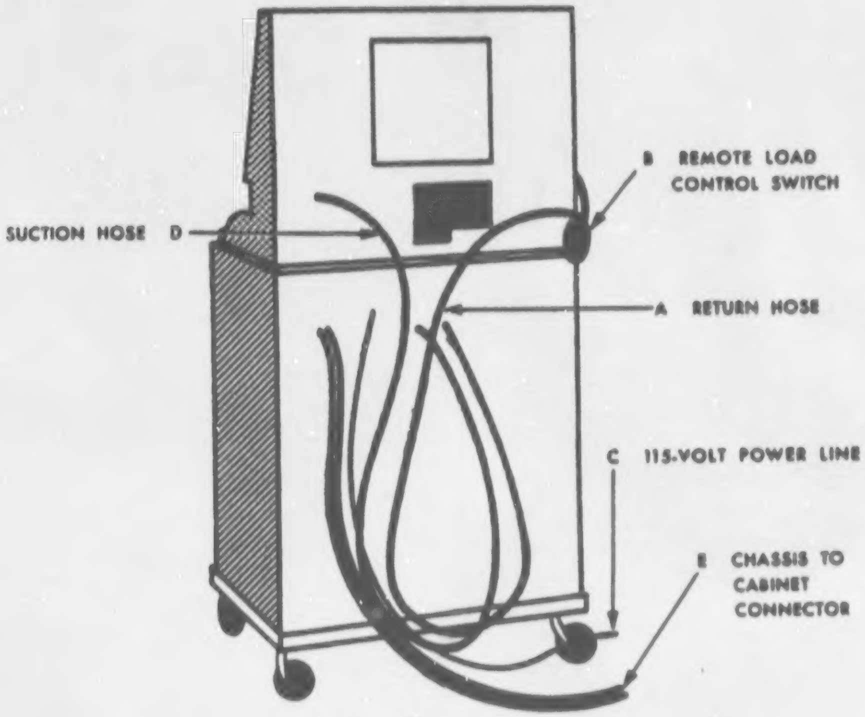
23. Provides a means of controlling the flow of water (cooling water).

24. Provides a connection to a 6-volt power supply for the exhaust gas analyzer.

? ?

156

Frame 13.


B REMOTE LOAD CONTROL SWITCH
SUCTION HOSE D
A RETURN HOSE
C 115-VOLT POWER LINE
E CHASSIS TO CABINET CONNECTOR

QUESTIONS 25 through 29.

? ?

Use the drawing above while answering these questions.

25. Provides a means of drawing water from the vehicle radiator into the auxiliary cooling system.

26. Provides a way to control the load on the vehicle during operation and tests.

27. Provides a means of returning water to the vehicle's radiator.

28. Provides 115-volt electrical power to the dynamometer cabinet.

29. Provides a connection between the sensing units on the dynamometer chassis and the instruments on the cabinet.

? ?

Frame 14.

QUESTIONS 30 through 34.

? ?

Read each of the following statements and then select the correct answer from the list. Blacken the appropriate space on your answer sheet for each question. Each question will have only one correct answer.

30. Provides a means of drawing water from the vehicle's radiator into the auxiliary cooling system.
31. Provides a means of switching the vehicle auxiliary pump on or off.
32. Provides a way to control the load on the vehicle during operation and tests.
33. Provides a means to return the water to the vehicle's radiator from the auxiliary cooling system.
34. Provides a way of controlling the flow of cooling water.

a. Cooler pump switch.
b. Radiator return hose.
c. Radiator suction hose.
d. Remote load control.
e. Cooling water control valve.

? ?

Frame 15.

QUESTIONS 35 through 39.

? ?

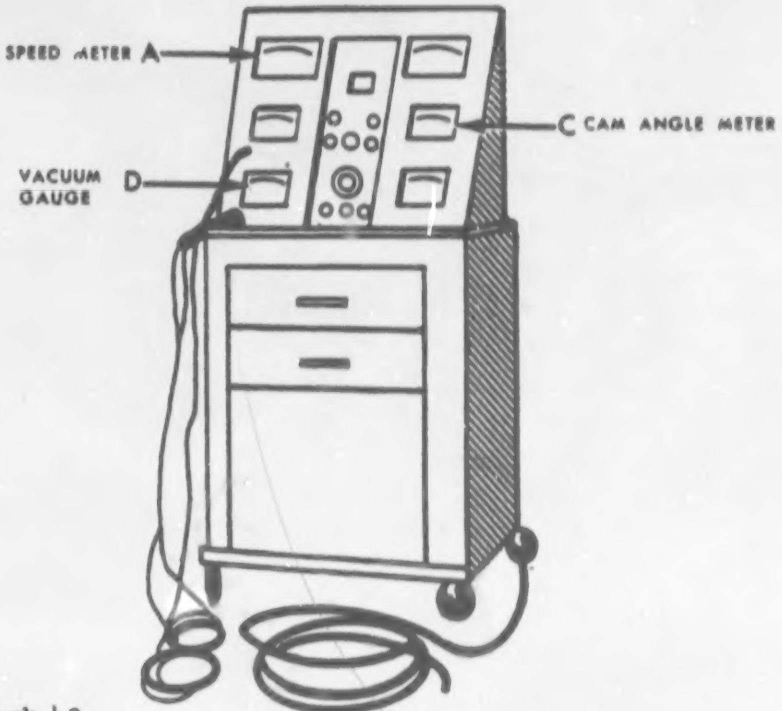
Read each of the following statements and then select the correct answer from the list. Blacken the appropriate space on your answer sheet for each question. Each statement will have only one correct answer.

35. Provides a way to fill the vehicle's radiator if needed.
36. Provides a 115-volt electric power supply to the dynamometer cabinet.
37. Provides a connection to the vehicle's ignition system to sense cam angle and engine RPM.
38. Provides a connection to the vehicle's tailpipe to sense the quality of exhaust gas.
39. Provides a connection between the sensing units on the dynamometer chassis and the instruments on the cabinet.

a. Instrument cable.
b. Exhaust gas pickup hose.
c. Distributor test leads.
d. 115-volt power cable.
e. Radiator fill valve.

? ?

Frame 16.


SPEED METER A
C CAM ANGLE METER
VACUUM GAUGE D

QUESTIONS 40 through 42.

? ?

? Match each of the statements below to the letter which shows that component in the drawing above. ?

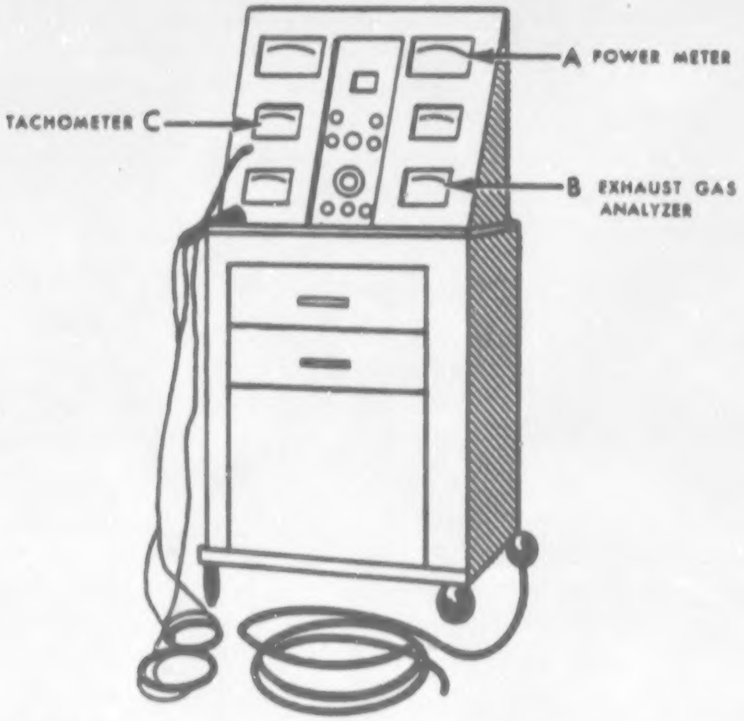
? ?

? 40. Indicates the time in degrees that the distributor points are closed. ?

? 41. Indicates manifold pressure in inches of vacuum. ?

? 42. Indicates the road speed of the vehicle in miles per hour. ?

? ?


A POWER METER
TACHOMETER C
B EXHAUST GAS ANALYZER

QUESTIONS 43 through 45.

? ?

? Match each of the statements below to the letter which shows that component in the drawing above. ?

43. Indicates fuel/air ratio and combustion efficiency.

44. Indicates the speed of the engine in revolutions per minute.

45. Indicates the road horsepower being produced by the vehicle and used up by the chassis dynamometer.

? ?

Frame 18.

QUESTIONS 46 through 49.

? ?

Match each statement below to the correct answer.

46. Provides a connection to the intake manifold of the engine to sense manifold vacuum.

47. Provides a connection to a 6-volt power supply for the exhaust gas analyzer.

48. Indicates the road horsepower being produced by the vehicle and used up by the chassis dynamometer.

49. Indicates the speed of the engine in revolutions per minute.

a. Tachometer.

b. Power meter.

c. Exhaust gas analyzer 6-volt power supply leads.

d. Vacuum hose.

? ?

QUESTIONS 50 through 53.

? ?

Match each statement below to the correct answer.

50. Indicates the fuel/air ratio and combustion efficiency.

51. Indicates the road speed of the vehicle in miles per hour.

52. Indicates manifold pressure in inches of vacuum.

53. Indicates the time in degrees that the distributor points are closed.

a. Speed meter.

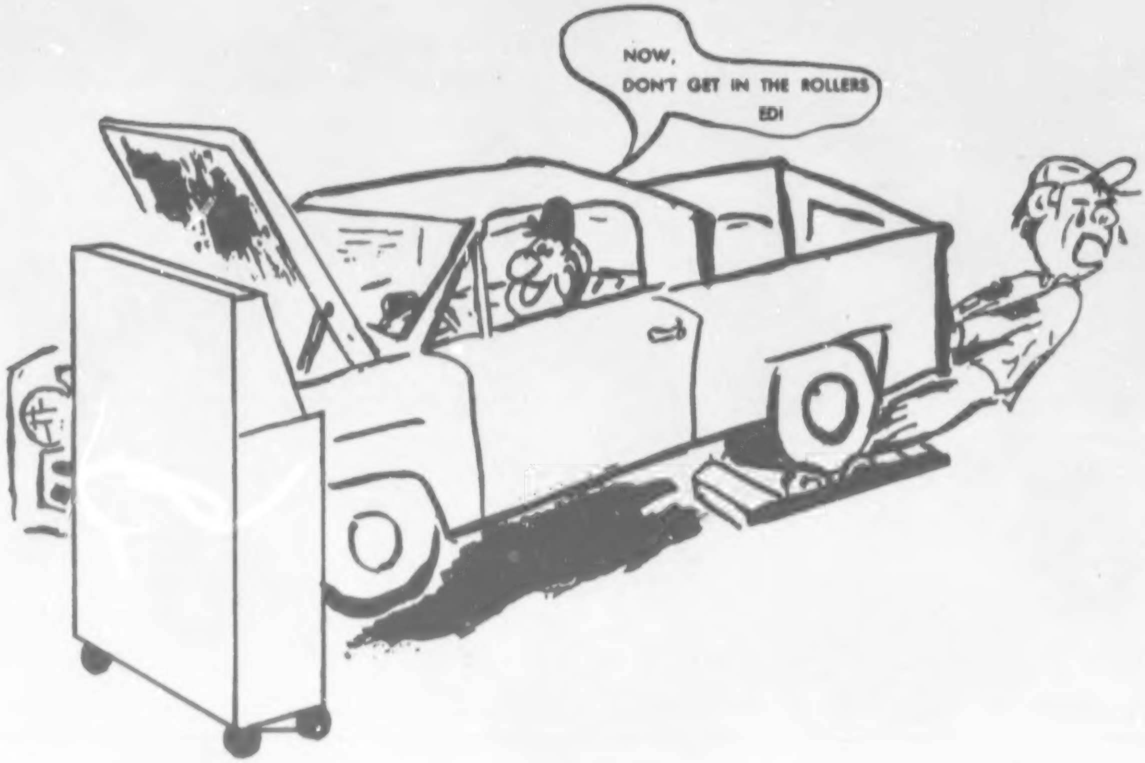
b. Cam angle meter.

c. Vacuum gauge.

d. Exhaust gas analyzer.

? ?

Frame 19.


NOW,
DON'T GET IN THE ROLLERS
ED!

QUESTION 54.

? ?

? Study the drawing above, the select the statement from those given ?
below which best tells how this accident could have been prevented.
? ?

a. Always lock the idle roller during operation.

? ?

b. Make sure all personnel stay clear of the rollers during operation.

? ?

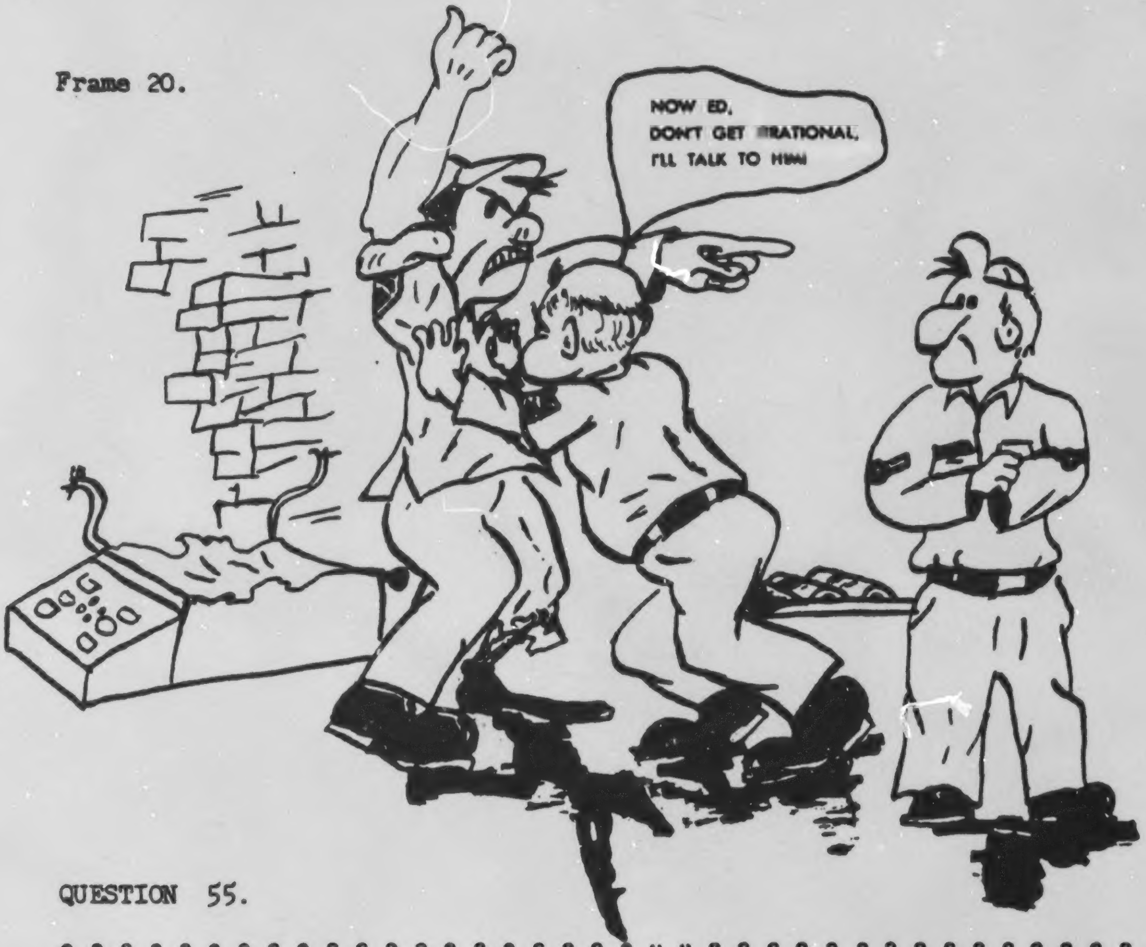
? c. Never release the clutch when the vehicle is in gear. ?

? d. Lock the wheels with the parking brake when the vehicle is in operation. ?

? ?

? ?

Frame 20.



QUESTION 55.

? ?

? According to the picture above, which of the following statements is correct? ?

? ?

a. Be ready to stop the vehicle in the event of an accident, always chock the front wheels, and never get out of the vehicle during operation.

b. Always turn off the 115-volt power supply before operation.

c. Always lock the brake pawl during operation.

d. Always lock the wheels with the parking brake and unchock the front wheels during operation.

? ?

PART II

DYNAMOMETER OPERATION AND TESTS

You have now completed Part I of the chassis dynamometer lesson. Part II of this lesson will be the actual operation of a vehicle on the dynamometer with YOU at the controls.

If you have been assigned the necessary tools and equipment and have been directed to use a specific dynamometer and vehicle, you may proceed to the next frame.

If you have not been given specific instructions as to what vehicle and dynamometer to use, CONSULT YOUR INSTRUCTOR NOW.

Frame 21.

INSTRUCTIONS

Part II of this lesson is designed to direct you through each and every phase of the chassis dynamometer operation except the operation of the flywheel. You will be required to perform certain tasks and record several readings as taken from the dynamometer indicators.

One very important thing to remember in this part of the lesson is to read EACH WORD VERY CAREFULLY. Each frame has been designed in such a way as to let you proceed systematically through each task and test. DO NOT accomplish any task that is not specifically called for in the frame. To do so would only jepordize your own safety and the safety of others in the shop area.

There will be two students assigned to this project. It is suggested that one student operate the vehicle while the other assists and observes. As soon as all tests have been completed by the first student then you may switch positions.

There is not a full-time instructor standing by your side during these tests. However, an instructor who is a technical expert is available for your use. A good policy to establish for yourself is "IF YOU ARE NOT SURE, CONSULT AN INSTRUCTOR!"

Complete ONE step at a time. Read each word carefully. Take your time.

You may now proceed to Frame 22, Step 1.

⇩

Step 1.

Before attempting to opemate the dynamometer or the vehicle, there are a few things that must be taken care of.

DO THE FOLLOWING THINGS.

1st - Check the crankcase oil level in the vehicle. If the oil level is okay, go on with the other tasks listed in this step. If the oil level is LOW, consult an instructor.

2nd - Check the coolant level in the vehicle's radiator. Fill it if necessary.

3rd - Check and regulate the tire pressures.

NOTE: Make sure all of the above tasks have been completed before going on to the next step.

⇩

Step 2.

ADVISORY: Read this entire step before attempting the task.

You are now ready to place the vehicle on the dynamometer. In this course of instruction, the vehicle is always backed onto the dynamometer.

Now, start the vehicle and back it onto the dynamometer rollers. Use extreme caution. Back the vehicle onto the rollers as straight as possible.

Frame 23.

Step 3.

Now, the vehicle must be "centered" on the rollers. That is, the rear wheels of the vehicle must be in the approximate center of the rollers and at the same time, in line with the front wheels.

DO THIS NOW: Place the vehicle in "high" gear and carefully and slowly start the rear wheels to turning. When the wheels start to turn, they will "line" up with the front wheels. "Drive" the vehicle for a few seconds.

NOW - Place the transmission in "neutral" and leave the engine running. Get out of the vehicle and check the position of the rear wheels, then answer the following question.

QUESTION

? ?

? Do not record your answer. There are no questions in this part of ?
the lesson which require you to write an answer or blacken a space.
? Just answer the question in your own mind and do what the answer says.?

? Are the rear wheels in the approximate center of the dynamometer ?
rollers?
? ?
YES - Good! Go on to the next step.
? ?
NO - Bad! Consult your instructor. He will assist you in re-
? moving the vehicle from the rollers and repositioning it. ?

? ?

Step 4.

Connect the "shop exhaust vent" to the vehicle's tailpipe. This will allow the engine exhaust to be vented outside instead of into the shop area.

Step 5.

Chock the front wheels of the vehicle using the metal chocks.

Step 6.

The vehicle is still "idling" and the transmission is in "neutral." This means that the rear wheels may be turned by hand.

NOW - Turn the rear wheels slowly by HAND and remove all foreign objects from the tire treads. This is a safety factor.

Step 7.

Turn the vehicle's engine OFF.

Step 8.

Move the dynamometer cabinet close to the left front fender of the vehicle and at an angle that will be easy to see from the driver's seat of the vehicle.

NOW - Turn the COOLER SWITCH to the OFF position. This switch is located on the cabinet base under the meter panels.

Frame 25.

Step 9.

The Clayton Chassis Dynamometer is electrically wired to a permanent type of wiring, however, a switch is provided to activate the equipment. This switch is located on the wall to the rear of the dynamometer chassis.

NOW - Turn this switch on.

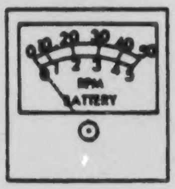
Step 10.

Located near the electrical switch is a water valve. When this valve is open, water flows to the power absorption unit of the dynamometer.

OPEN this valve now.

Step 11.

Located on the RPM meter is a knurled thumb screw. Turn this screw until the RPM needle is on "O." This calibrates the meter. Consult the accompanying illustration if necessary.



QUESTION.

? ?

? Did the RPM needle set to "O?" ?

? YES - Good, you may proceed to the next step. ?

? NO - Re-read the instructions and try again. Consult an instructor if necessary. ?

? ?

Step 12.

The DWELL METER must also be set on "0." It is "zeroed" in the same manner as the RPM meter.

Turn the knurled thumb screw on the dwell meter until the needle is resting on "0." Do this now.

QUESTION.

? ?

? Is the Dwell meter needle on "0?" ?

? YES - Jolly good! You know what to do so go on. ?

? NO - Hmmmmm - you goofed. Read Step 12 again. You can do it. ?

? ?

Step 13.

Located between the RPM meter and the dwell meter is a toggle switch marked "6-12" and "24" volt. Determine the battery voltage of the vehicle you are working with and set the toggle switch to the position that correspondr with that voltage.

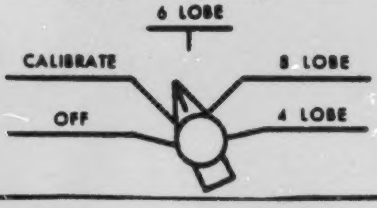
EXAMPLE: If your vehicle has a 12-volt battery, then simply set the toggle switch in the "6-12" position.

Frame 27.

Step 14.

Located between the RPM meter and the dwell meter is a switch that is marked "OFF," "CALIBRATE," "6 LOBE," "8 LOBE," and "4 LOBE."

Turn this switch to the CALIBRATE position now. Consult the accompanying illustration if need be.



Step 15.

Now that the switch is in the CALIBRATE position, the RPM needle should be in the black area marked "BATTERY CHECK." Check the needle position and then answer the question below.

QUESTION.

? ?

? Is the RPM needle in the BATTERY CHECK area? ?

? YES - You don't have to be told what to do now do you? ?

? NO - WHOA......Don't do anything else right now except consult ?
an instructor. The RPM meter needle is battery-operated
? and like most batteries, will sometimes fail. Your instruc-?
tor will replace the meter battery for you.
? ?

DO NOT PROCEED UNTIL THE RPM METER NEEDLE IS IN THE "BATTERY CHECK"
? AREA. ?

? ?

Frame 28.

Step 16.

NOW - Turn the DWELL REGULATOR knob, located between the dwell meter and the RPM meter, until the DWELL METER needle lines up on the "SET" line.

Step 17.

Located between the SPEED meter and the HORSEPOWER meter are two toggle switches marked "HI" and "LO."

Set BOTH of these switches in the "LO" positions.

Step 18.

Located between the RPM meter and the dwell meter is a switch marked "5000 RPM" and "1000 RPM."

Turn the switch to the "5000 RPM" position.

INFORMATIONAL NOTE: You may want to know why the RPM switch is set to "5000." It's fairly simple. The RPM meter is designed to record RPM's to 5000 and 1000. The top scale of the meter reads to 5000 and the lower scale reads to 1000. You will be operating your vehicle at 2500 RPM, so it stands to reason that you will have to use the top scale.

Frame 29.

Step 19.

Observe the wire, with two leads, coming from the side of the cabinet nearest the dwell meter. This wire controls the RPM and dwell meters and is connected in the following manner:

1st - Connect the RED lead to the distributor side of the coil or to the primary side of the distributor.

2nd - Connect the BLACK lead to any good ground. (The engine block is a good ground.)

Step 20.

Turn the vehicle's ignition switch ON.

Observe the dwell meter. If the dwell meter needle is setting on "0", this is an indication that the distributor points are OPEN. Right now you want the points to be closed.

Tap the vehicle starter switch very gently until the dwell meter goes toward the BLACK BAR area. This is an indication that the points are closed.

With the points closed, the dwell meter should indicate 47 degrees or more, which means that the points are satisfactory. HOWEVER, if the dwell meter is not stable, that is the needle keeps dropping down on the scale, this is an indication of excessive resistance in the points.

Go to Step 20 on your worksheet and fill in the necessary information.

Step 21.

Place the RPM/dwell meter calibration switch in the "LOBE" position which corresponds to the number of cylinders in the vehicle on which you are working.

EXAMPLE: If you are working with a 6-cylinder vehicle, place the lobe switch in the "6 LOBE" position.

NOTE: If you have forgotten what this switch looks like, you may refer back to Frame 27, Step 14.

Step 22.

Now, let's hook up the vacuum meter.

Located on the side of the cabinet nearest the dwell meter is a small hose with a red tip attached.

Disconnect the windshield wiper hose from the engine manifold and attach the vacuum hose to the manifold.

NOTE: If your vehicle does not have vacuum-operated windshield wipers, you will find an adapter on the manifold to attach the hose to. If there is no adapter, consult an instructor at once.

Frame 31.

Step 23.

Now, we can insert the cooler hoses into the vehicle's radiator.

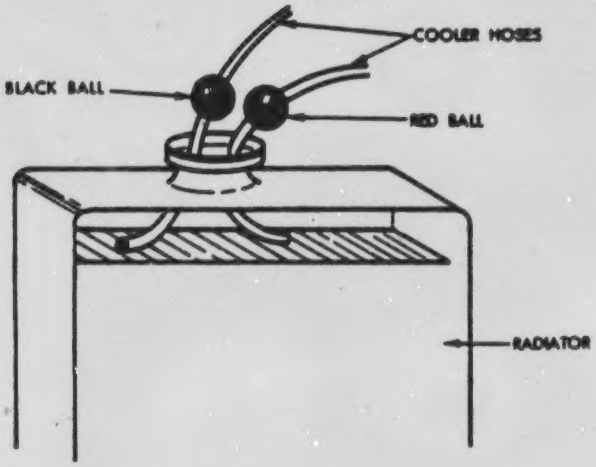
Although this task is fairly simple, there are certain things that must be done in order to afford maximum cooling.

Remove the radiator cap. Remove the cooler hoses from the rear of the dynamometer cabinet. OBSERVE that one hose has a black ball attached to it and the other has a red ball. The BLACK BALL hose is the suction hose and the RED BALL hose is the return hose. Place the hose nozzles in the radiator in the following manner:

Place the RED BALL NOZZLE inside the radiator tank so that it is pointing to your LEFT.

Place the BLACK BALL NOZZLE inside the radiator tank so that it is pointing to your RIGHT.

These nozzles must be separated to maintain constant circulation. (Consult the diagram below, if you wish.)



Step 24.

Turn the cooler switch to "ON." Remember, this switch is located on the base of the cabinet below the meters.

Step 25.

Start the vehicle's engine.

Step 26.

ADVISORY: READ THIS ENTIRE STEP BEFORE PROCEEDING WITH THE TASKS.

Take the dynamometer remote load control switch and hold it in either hand. You will observe that the switch has two small buttons marked "ON" and "OFF."

NOW - Put the vehicle in "high" gear and set the rear wheels in motion. Speed up the vehicle SLOWLY until the SPEED meter on the cabinet indicates approximately 30 MPH.

NOW - Push the "ON" button and hold it momentarily. When you notice the vehicle being "bogged" down, release the "ON" button.

NOW - After operating the vehicle for a few seconds under "load," release the load by depressing the "OFF" switch.

REPEAT this operation for 3 or 4 minutes to familiarize yourself with the load control switch and to allow the vehicle to "warm up."

CAUTION!!!!!!! AT NO TIME during the above operation should you let the vehicle go beyond 40 MPH.

NOW - Put the vehicle transmission in "neutral" and leave the engine idling.

Frame 33.

⇩

Step 27.

Turn the COMBUSTION ANALYZER switch (bottom of meter panel) to the BATTERY position.

⇩

Step 28.

ADJUST the BATTERY REGULATOR knob on the cabinet until the COMBUSTION ANALYZER needle is on the SET line.

⇩

Step 29.

TURN the combustion analyzer switch to the COMBUSTION position. ADJUST the COMBUSTION REGULATOR until the analyzer needle is on the SET line.

Frame 34.

Step 30.

Get the air hose (located at the rear of the dynamometer chassis) and BLOW OUT the EXHAUST CONDENSER UNITS.

CAUTION!!!!!! Blow out the condenser can from the inlet side ONLY.

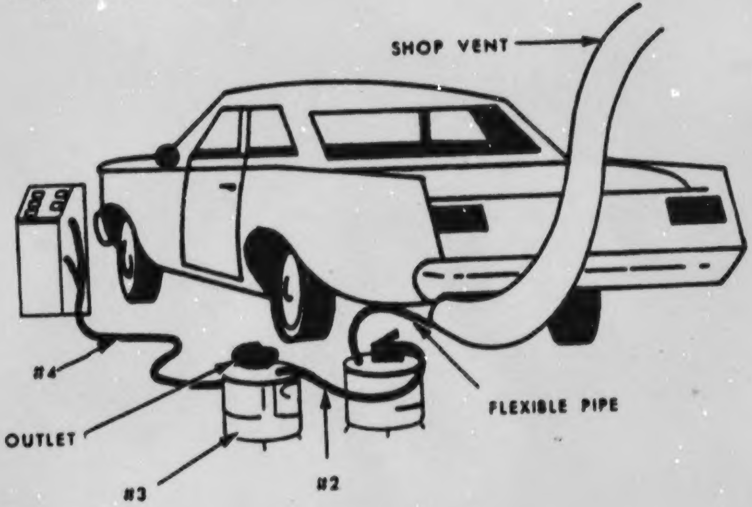
CONNECT the units as shown in the drawing below.

1st - Place the metal flexible hose well into the tailpipe (approximately 8 inches) and replace the shop vent pipe.

NOTE: Some shop vent pipes have a small hole in them for this very purpose.

2nd - Connect the cans with the short hose (#2).

3rd - Connect the long hose (#4) to the OUTLET side of the condenser can and then to the dynamometer cabinet (near the combustion analyzer meter).



Frame 35.

Step 31.

Now that you have the exhaust condenser units connected, allow the EXHAUST ANALYZER to operate for approximately two (2) minutes.

Step 32.

After you have operated the exhaust analyzer for approximately two minutes, as required in Step 31 above, DISCONNECT the long hose from the combustion analyzer.

Step 33.

When the exhaust condenser units are first connected to the combustion analyzer, condensation may form in the analyzer meter. When the hose is disconnected for a few seconds the condensation has a chance to dry up. However, as a result of this condensation, the analyzer may have to be re-calibrated.

If the long hose is disconnected, you may now proceed to Step 34.

⇩

Step 34.

Re-calibrate the combustion analyzer, if need be, by turning the COMBUSTION REGULATOR until the needle is again on the SET line.

Reconnect the long hose to the analyzer.

☼

Step 35.

ADVISORY - READ THIS ENTIRE STEP BEFORE PROCEEDING WITH THE TASKS.

The chassis dynamometer is now prepared for use. The next five steps of this lesson are very important to you because they contain the five basic tests to be made with the dynamometer. You will be required to take certain readings from the meter panel, listen for certain noises, and record all of these items on your worksheet. Take your time and do exactly as directed.

Because you are simulating actual road conditions with the dynamometer, there will be a good deal of noise present during these tests. Do not become alarmed at all of this noise.

CAUTION !!!!!! DO NOT GET OUT OF THE VEHICLE WHILE THE TRANSMISSION IN IN GEAR. If you must get out of the vehicle, PUT THE TRANSMISSION IN NEUTRAL.

Frame 37.

Step 36.

TEST I - FULL THROTTLE 2500 RPM

ADVISORY: READ THIS ENTIRE STEP BEFORE PROCEEDING WITH THE TASKS.

Put the vehicle in "high" gear and start the rear wheels turning.

LOAD the dynamometer (using the remote load control switch) until the engine is operating at FULL THROTTLE (accelerator on the floor) and the RPM meter indicating 2500.

NOTE: This may be difficult to achieve at first. Increase engine speed gradually as you depress the "ON" button.

NOW - With the vehicle operating at full throttle and 2500 RPM, complete Step 36 on your worksheet.

Step 37.

TEST II - VALVE OPERATION TEST

ADVISORY: READ THIS ENTIRE STEP BEFORE PROCEEDING WITH THE TASKS.

While the vehicle is operating at full throttle and at 2500 RPM, SHIFT THE TRANSMISSION INTO NEUTRAL and let the engine come to idle. DO NOT UNLOAD THE DYNAMOMETER.

NOTE: When the engine is coming to idle, the radiator may overflow. To prevent this, tap the accelerator lightly before the engine gets all of the way to idle.

NOW - When the engine is at idle, complete Step 37 on your worksheet.

Step 38.

TEST III - POWER SYSTEM CUT-IN TEST

ADVISORY: READ THIS ENTIRE STEP BEFORE PROCEEDING WITH THE TASKS.

The dynamometer is still loaded and the engine is idling.

NOW - Shift the transmission into "high" gear ans start the wheels turning.

SLOWLY increase the speed until the MANIFOLD VACUUM reaches 10 inches. Pause at 10 inches until the exhaust analyzer has stabilized.

OPEN the throttle SLOWLY and observe the exhaust analyzer. When the exhaust analyzer indicator moves toward the RICH side of the meter, note this reading and record it on your worksheet on Step 38. Remember, the reading when the indicator started to move is the reading that is to be recorded.

Step 39.

TEST IV - ACCELERATION TEST

ADVISORY: READ THIS ENTIRE STEP BEFORE PROCEEDING WITH THE TASKS.

With the dynamometer still loaded, reduce engine speed to approximately 15 MPH.

QUICKLY open the throttle (accelerator to the floor) and at the same time UNLOAD THE DYNAMOMETER. CAUTION !!!!!! Do not let the vehicle speed go beyond 60 MPH during this test.

Shift the transmission into "neutral" and complete Step 39 on your worksheet.

Frame 39.

Step 40.

TEST V - PART THROTTLE TEST

ADVISORY: READ THIS ENTIRE STEP BEFORE PROCEEDING WITH THE TASKS.

BALANCE the load and throttle until you obtain 40 MPH and 10 HP. This is called "cruising index." When you have obtained cruising index, lay the remote control switch to one side.

NOW - Without changing the load, increase the engine speed up to 2500 RPM.

COMPLETE Step 40 on your worksheet.

You have now completed the testing phase of this lesson. The next thing to do is to remove the vehicle from the dynamometer. Although this is a fairly simple task, it will have to be accomplished in a definite sequence. Follow the procedures outlined in Step 41.

Step 41.

Follow these procedures carefully to remove the vehicle from the dynamometer.

1st - Turn the engine off.

2nd - Disconnect the long hose (condenser hose) from the cabinet.

3rd - Turn the cooler switch to "OFF" and remove the hoses from the radiator.

4th - Remove the dwell meter wires.

5th - Remove the vacuum gauge hose and replace the windshield wiper hose.

6th - Turn the lobe indicator switch to the "OFF" position.

7th - Push the cabinet to one side and out of the way of the vehicle.

8th - Turn the exhaust analyzer switch to the "OFF" position.

9th - Remove the front wheel chocks.

10th - Remove the shop exhaust vent from the tailpipe.

11th - Disassemble the exhaust condenser units and blow them out.

12th - Turn the main power switch (on the wall) to "OFF."

13th - Turn the water supply valve (on the wall) off.

14th - Engage the drive roller brake pawl. This pawl is located on the end of the front (drive) roller.

15th - Make a quick check to see that all tools and equipment are in the same position as when you started.

16th - Drive the vehicle straight off the dynamometer and park it approximately 10 feet from the dynamometer chassis.

17th - Go to Step 42.

Frame 41.

Step 42.

All during this lesson you have been leading up to a point where you can analyze vehicle performance and make certain decisions. Malfunctions, as you learned from the testing phase, show up in many different ways in a vehicle. Because of this, reason rather than rule plays the most important role in the detection of vehicle malfunctions. It would be impossible to make a rule governing each and every trouble that could exist in a vehicle. So now it becomes necessary to analyze a problem and use common sense, accompanied by manufacturer's specifications, to determine these areas of malfunction.

In the next few frames you will be given narratives depicting troubles you would most likely find in operating a vehicle on the chassis dynamometer. You will be asked questions about the narrative. Analyze the questions carefully, then, select a correct answer for each question from a given group of possible solutions.

Mark your answers on the same answer sheet as you used with Part I of this lesson. Begin with answer 56 on the answer sheet.

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PART III

ANALYSIS OF THE CHASSIS DYNAMOMETER

1

Frame 42.

ADVISORY: Read this entire narrative before attempting to answer any of the questions. You may refer to this narrative at any time.

If you recall when you were making the basic tests on the dynamometer, one of the items you had to note was horsepower. Let's say that while operating the vehicle at full throttle and 2500 RPM, you heard a sucking noise at the tailpipe, you observed "popping" through the carburetor, and low horsepower was indicated on the meter. Would bad piston rings cause this? Excessively worn rings would show up as excessive blowby at the oil breather, but then this wasn't one of your indications was it? How about compression? This is probably your trouble but how do you determine this? If you had a blown head-gasket you should have air bubbles in the radiator and could possibly hear a "hissing" noise in the engine. But then, these were not things you observed during the test were they? If everything else has been checked, then the only "compression components" left would be the valves. It is always important to include a valve operation test in the dynamometer tests because sticking or burned valves will show up as "popping" through the carburetor and "sucking" at the tailpipe.

Now, answer the next three questions using the information in the above narrative to assist you.

QUESTIONS 56 through 58.

? ?

56. Equally low horsepower on adjacent cylinders, air bubbles in the radiator, and an audible hissing sound at the engine would indicate a malfunction in which of the following components?

a. Intake valves.

b. Exhaust valves.

c. Headgasket.

d. Piston rings.

57. While operating a vehicle on the dynamometer at full throttle and 2500 RPM, you had "backfiring" in the carburetor and the road horsepower wasn't up to specifications. What is the most probable cause of this?

a. Broken piston rings.

b. Blown headgasket.

c. Valves.

d. Carboned rings.

58. During vehicle operation you observe a good deal of blowby. (Blowby is smoke coming from the oil breather.) What would normally cause this?

a. Rings.

b. Valves.

c. Headgasket.

d. None of the above.

? ?

Frame 44.

The ignition system of a vehicle is a very important and critical system. All of the components of the ignition system must function properly in order to achieve maximum horsepower. For example, a malfunction in the primary ignition system would probably show up as a high speed mis-fire, and a secondary ignition malfunction would show up as a low speed mis-fire. This would be true only if all other systems had been checked and found satisfactory. Many things could cause a vehicle to be extrememly "sluggish." Among these things are carburetion and basic timing. Let's go back to horsepower again. In the narrative just prior to this one, we said that a lack of horsepower could be caused by sticking or burned valves. That is, if the vehicle is operating at full throttle and at 2500 RPM. But, what if you had a lack of horsepower during acceleration? This could be caused by either carburetion or the advance system. So you see, a lot of things must be considered before you commit yourself to an analysis of the problem.

Answer the four questions in the next frame using the information in the above narrative to assist you.

Frame 45.

QUESTIONS 59 through 62.

? ?

59. The vehicle is extremely sluggish. Carburetion is satisfactory. What is the problem?

a. Primary ignition.
b. Secondary ignition.
c. Basic timing.
d. Advance system.

60. When accelerating on the dynamometer, under load, you observed low horsepower. A compression check revealed satisfactory valves. What is the problem?

a. Basic timing.
b. Advance system.
c. Primary ignition.
d. Secondary ignition.

61. A high speed mis-fire is not probably caused by a malfunction in which of these components?

a. Secondary ignition.
b. Primary ignition.
c. Basic timing.
d. Advance system.

62. A low speed mis-fire indicates problems in which of these components?

a. Secondary ignition.
b. Primary ignition.
c. Basic timing.
d. Advance system.

? ?

Frame 46.

Carburetion is probably one of the worst enemies of vehicle operators. Operators complain of poor gas mileage, poor acceleration, rough idle, and many other things but they do not have a procedure to follow in isolating these problem areas. Now don't misunderstand. The problems listed above are carburetion malfunctions but by no means are they restricted to carburetion. Let's consider some problems. The exhaust gas analyzor shows that you have a rich misture. That is, you have too much fuel for the amount of air you have entering the engine. Many things cause rich mixtures, among them being a clogged air cleaner. Perhaps even a closed or partly closed choke could also cause richness. Always check the air cleaner and choke, if the mixture is rich, and if you find problems, correct them. If the mixture leans out after cleaning the air cleaner or opening the choke, you have found the problem. But suppose that your problem is a lean mixture. The engine is starving for fuel. Could be that a fuel pump volume test is in order or maybe a check for fuel line restrictions. But let's look at the vacuum meter for a second or two. Suppose that you are operating in full throttle at 2500 RPM. The vacuum reading should be approximately 1 inch but the meter indicates 3 inches of vacuum. The throttle must be fully open and the choke fully open if you ever expect to attain proper vacuum.

So, carburetion is not so simple after all, is it? Answer the next three questions. Try not to use the narrative again unless you have to. Think of the question as a test on the dynamometer and make some general deductions in your mind.

QUESTIONS 63 through 65.

63. The vehicle is operating at full throttle and 2500 RPM. AFR is lean. Where is the problem?

a. Fuel starvation.

b. Restricted air cleaner.

c. Closed choke.

d. Partly open throttle.

64. The vacuum reading is much too high at full throttle and 2500 RPM. What could cause this?

a. Rich mixture.

b. Lean mixture.

c. Fuel starvation.

d. Throttle partly closed.

65. AFR is very rich. What's the problem?

a. Full open throttle.

b. Full open choke.

c. Restricted air cleaner.

d. Fuel starvation.

Frame 48.

How are you at identifying drive line noises? Did you know that certain noises may travel to other parts of the drive line and sound like they are coming from a certain component when actually they aren't. For example, a noisy transmission may actually sound like a growling differential. So, it is important that we establish certain ground rules to follow while determining drive line noises. Although we do not use the flywheel in this lesson, it would be necessary to have it engaged in order to detect certain drive line noises. So, we will build typical problems and just assume that the flywheel is engaged.

While shifting the vehicle through its gears, you notice a sudden buildup of RPM but you detect only a slight change in speed. At the same time, you hear and feel a "chatter." It is obvious that the clutch is faulty. But suppose the vehicle has a howling or humming noise coming from the chassis. Naturally, this noise can be isolated to the transmission or to the rear axle components. The easiest and quickest way to determine where the noise is coming from is to have another person listen for the noise while you operate the vehicle. Other than these few problems and the distinct popping and snapping sound of a faulty universal joint, not many other noises should be audible. Again, reason rather than rule will dictate.

Let's answer these last three questions now.

QUESTIONS 66 through 68.

? ?? ? ? ? ? ? ?? ?

? 66. An increase in RPM with no appreciable increase in speed and a chattering noise is indicative of problems in which area of the vehicle? ?

? a. Transmission. ?

? b. Differential. ?

? c. Clutch. ?

? d. Universal joints. ?

? 67. You detect a howling or humming noise coming from the chassis. The transmission has been checked and found satisfactory. Where would your problem most likely be? ?

? a. Rear axle components. ?

? b. Drive shaft. ?

? c. Universal joints. ?

? d. Transmission. ?

? 68. When shifting through the gears, you hear a "snapping" or "popping" each time you engage the clutch. Where is this noise coming from? ?

? a. Differential. ?

? b. Transmission. ?

? c. Rear axle components. ?

? d. Universal joints. ?

? ?

This lesson is now complete. Place all written material together and report with them to the work control center.

Frame 50

QUESTION CONFIRMATION

1. b
2. a.
3. b.
4. b.
5. a.
6. b.
7. b.
8. c.
9. d.
10. a.
11. d.
12. b.
13. b.
14. a.
15. b.
16. c.
17. c.
18. a.
19. e.
20. d.
21. a.
22. b
23. c
24. e
25. d
26. b
27. a
28. c
29. e
30. c
31. a
32. d
33. b
34. e
35. e
36. d
37. c
38. b
39. a
40. c
41. d
42. a
43. b
44. c
45. a
46. d
47. c
48. b
49. a
50. d
51. a
52. c
53. b
54. b
55. a
56. c
57. c
58. a
59. c
60. b
61. a
62. a
63. a
64. d
65. c
66. c
67. a
68. d

INSTRUCTIONS

Follow the directions of your instructor to complete the following.

STEP #20

With the distributor points closed, where did the dwell meter stabilize?

_______ degrees.

With the distributor points closed, did the dwell meter reading keep falling off?

_____ YES _____ NO

STEP #36

What were the following readings at full throttle and 2500 RPM?

Horsepower __________ Cam Angle ___________

Air/fuel ratio __________ Manifold vacuum ___________ inches.

During the test did any of the following things happen?

Did engine oil pressure drop? _____ YES _____ NO

Did engine mis-fire? _____ YES _____ NO

Did you observe excessive blowby? _____ YES _____ NO

Did engine power fluctuate? _____ YES _____ NO

Did you hear foreign noises? _____ YES _____ NO

Did the clutch slip? _____ YES _____ NO

Did the exhaust system leak? _____ YES _____ NO

Frame 52

STEP #37

Did the vacuum gauge fluctuate? ____ YES ____ NO

Did the engine idle roughly? ____ YES ____ NO

STEP #38

Vacuum reading: ____ inches.

STEP #39

Did the engine mis-fire? ____ YES ____ NO

Did you observe flatspots? ____ YES ____ NO

Was acceleration rough? ____ YES ____ NO

Did you notice detonation? ____ YES ____ NO

Did you hear foreign noises? ____ YES ____ NO

Did you notice backlash? ____ YES ____ NO

STEP #10

With the engine at part throttle and 2500 RPM, record the following information:

Air/fuel ratio ____________________

Manifold vacuum ____________________ inches.

Speed meter reading ____________________ MPH.

Vehicle speedometer ____________________ MPH.

Did the vacuum gauge fluctuate? _____ YES _____ NO

Did the engine mis-fire? _____ YES _____ NO

Did the generator charge? _____ YES _____ NO

Any foreign noises? _____ YES _____ NO

Any excessive vibration? _____ YES _____ NO

Were rear wheels unbalanced? _____ YES _____ NO

PREPARE THE MAN

PROGRAMMED TEXT 3ABR47~~330~~232-PT-404B

8-11

Technical Training

General Purpose Vehicle ~~Repairman~~ Mechanic

WEAVER
HEADLIGHT TESTER

28 August 1970

CHANUTE TECHNICAL TRAINING CENTER (ATC)

This supersedes CISDT PT-47-53, 13 February 1967.
OPR: TSDT
DISTRIBUTION: X
TSDT - 500; TSOC - 2

Designed For ATC Course Use

FOREWORD

This Programmed Text was developed for use in the 3ABR47330, Automotive Repairman Course in 1965. It was validated with students from the course, 90% of whom achieved the objectives as stated. The text has been used for over four years, with approximately 3,000 students, and is considered valid.

OBJECTIVES

When you have completed this programmed text, you will be able to

1. List the two-fold purpose of the weaver headlight tester.

2. List the major components of the weaver headlight tester.

3. Match a list of the major components with their location on the weaver headlight tester.

4. Determine the candlepower of headlights using the tester meter on the weaver headlight tester.

5. Properly aimed the headlights of a vehicle using the weaver headlight tester.

INSTRUCTIONS

Record all of your answers to questions on the standard answer sheet supplied you along with this package.

Notify your instructor when you have completed Part I of this program. He will assign you to a vehicle and provide the necessary equipment required so that you may complete the operation as called for in Part II.

August 1969

SAD STORY DEPARTMENT

Airman Harry Hirsute was coming back to base late one night from leave when an oncoming vehicle blinded him with its headlights. Harry dimmed his lights and the driver of the oncoming vehicle dimmed his also but Harry was still blinded. Harry drove off the shoulder of the road and blew a tire. By the time that Harry got the spare on, he was late in reporting back in from leave.

It is reasonable to assume that the oncoming vehicle had its headlights aimed improperly.

QUESTION 1.

The headlights in the above story were aimed

a. too high.

b. too low.

c. too wide.

Frame 2.

There are many factors which may cause headlights to blind oncoming traffic. One of these factors is excessive weight in the trunk. Another factor is too many passengers in the rear seat. Either of these factors will cause the front of the vehicle to ride higher than usual.

QUESTION 2.

If the front end of a vehicle is riding high, how will the headlights be aimed?

a. Too low.

b. Too far to the right.

c. Too far to the left.

d. Too high.

Now that you have an idea of how this program operates, no doubt you would like to know a little more about what you will be doing.

1. After completing the Programmed Package you will know:
   a. The purpose of the Weaver Headlight Tester.
   b. All the major components of the Weaver Headlight Tester.
2. After completing the Programmed Task List you will have:
   a. Determined the candle power of headlights.
   b. Properly aimed the headlights of a vehicle.

All vehicles, regardless of age or style, need to have their headlights adjusted at one time or another. Headlights become too high, too low, too far to the left or to the right.

QUESTIONS 3 and 4.

3. What is the best way to determine if the headlights need adjusting?

   a. Through the use of a headlight tester.

   b. With a screwdriver.

   c. By a road test.

   d. By the "guess" method.

4. The Weaver Headlight Tester used in this training program is an excellent way of determining if the

   a. headlights are burning.

   b. headlights are aimed properly.

   c. the vehicle has excessive weight in the rear.

Frame 4

The Weaver Headlight Tester is used to both aim the headlights and to test the candlepower of the headlights. That is, determine how bright the headlights are, and whether or not they come within specifications.

QUESTION 5.

What is the two-fold purpose of the Weaver Headlight Tester?

a. The Weaver Headlight Tester measures headlight candlepower.

b. The Weaver Headlight Tester determines if the headlights are aimed incorrectly.

c. The Weaver Headlight Tester measures headlight candlepower and determines if headlight adjustment is necessary.

The next few frames of this program will teach you the components of the Weaver Headlight Tester. Study these components carefully. You will be required to know all of them when you have completed the program.

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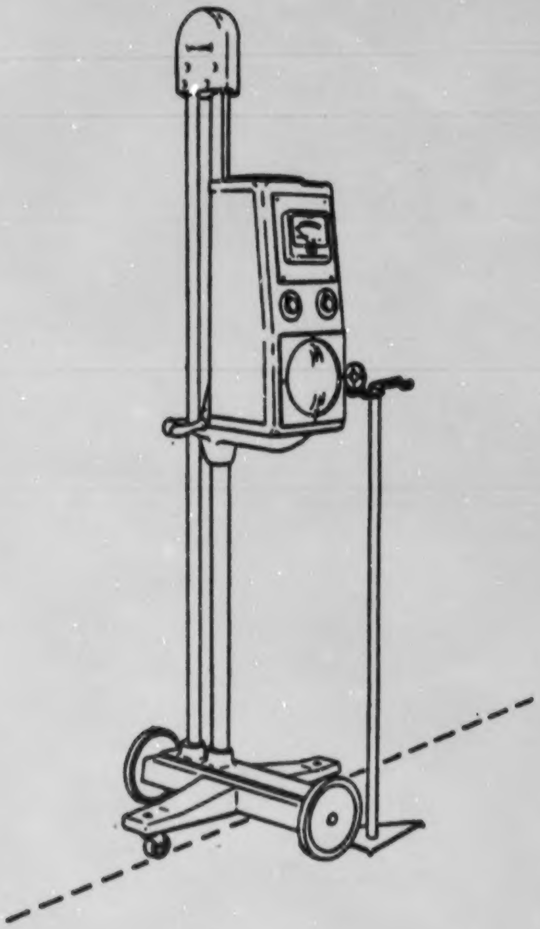
Frame 5.

The diagram below shows the equipment you will be required to operate later on in this program. Look over this diagram before going on to the next frame.



$23^{5}1$

Frame 6.

The first major component of the Weaver Headlight Tester that we will discuss is the tester case. The case houses a variety of mirrors, a meter for indicating candlepower, a dial for determining the high or low position of the headlights, and another dial for determining the left or right position of the headlights.

QUESTION 6.

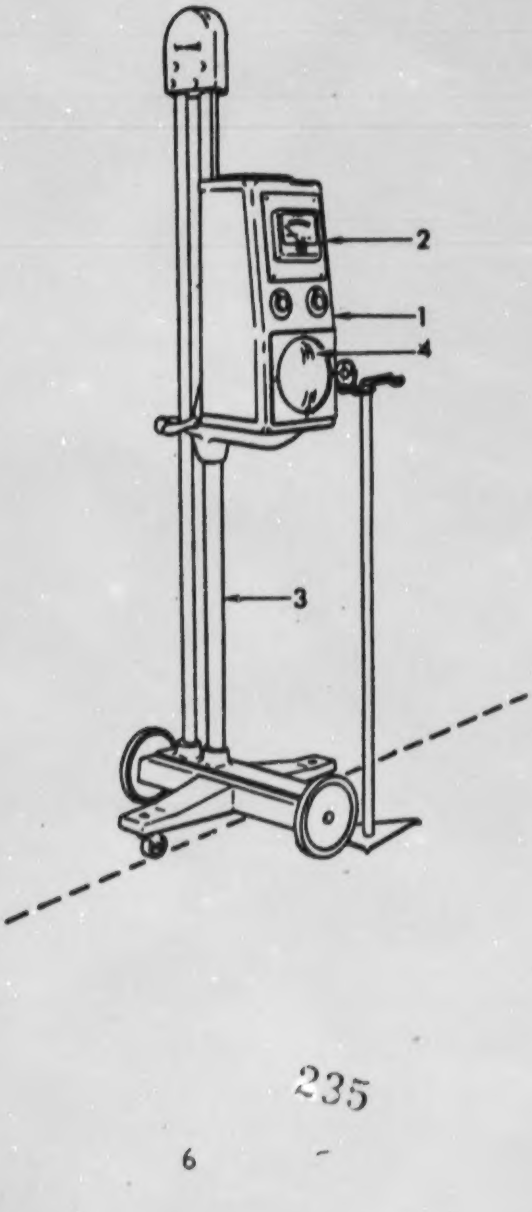
In the diagram below, which arrow points to the tester case?

a. Nr. 1.

b. Nr. 2.

c. Nr. 3.

d. Nr. 4.



The diagram below shows a cross-section of the tester case. Located directly on top of the case is a viewing window. If you look through the viewing window and toward the back of the case, you will observe a viewing mirror.

QUESTION 7.

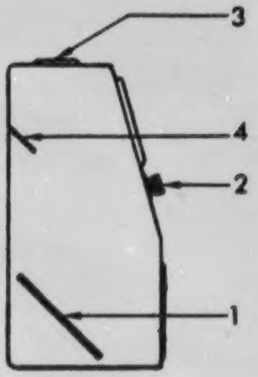
In the diagram below, which arrow is pointing to the viewing mirror?

a. Nr. 1.

b. Nr. 2.

c. Nr. 3.

d. Nr. 4.

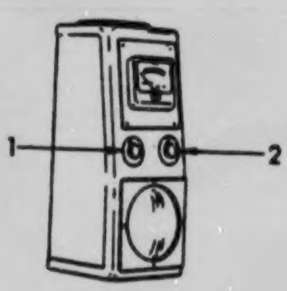


Frame 8

On the front of the tester case are two knobs, each of which has an arrow on it. The knob on the right is used for determining the high or low position of the headlights. The knob on the left is used to determine the left or right position of the headlight. Locate these two knobs in the diagram shown for the questions below.

QUESTIONS 8 and 9.

8. Which knob is arrow Nr. 1 pointing to in this figure?
   - a. The left-right position knob.
   - b. The high-low position knob.
   - c. The up-down position knob.



9. Which knob is arrow Nr. 2 pointing to in this figure?
   - a. The left-right position knob.
   - b. The high-low position knob.
   - c. The up-down position knob.

Study the diagram below and then use the following list of components to answer the next five questions.

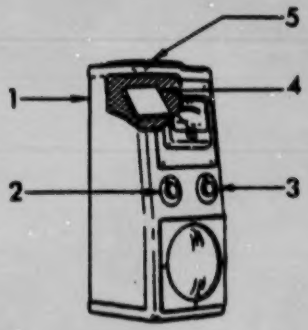
a. Left-right knob.

b. High-low knob.

c. Viewing window.

d. Viewing mirror.

e. Tester case.



QUESTIONS 10 through 14.

10. To which component is arrow Nr. 1 pointing?

11. To which component is arrow Nr. 2 pointing?

12. To which component is arrow Nr. 3 pointing?

13. To which component is arrow Nr. 4 pointing?

14. To which component is arrow Nr. 5 pointing?

Frame 10.

The tester case can be moved upward or downward on its frame by grasping the handles on the back of the tester case.

QUESTION 15.

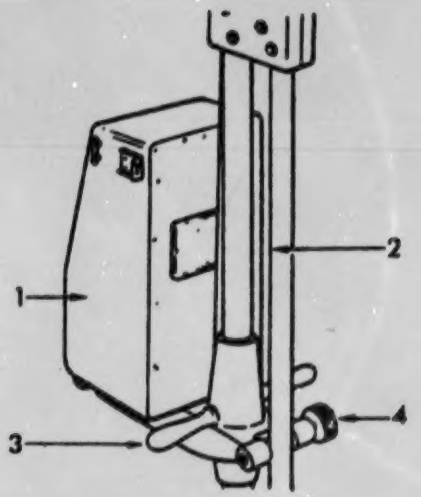
In the accompanying illustration, which arrow points to the tester handles?

a. Arrow Nr. 1.

b. Arrow Nr. 2.

c. Arrow Nr. 3.

d. Arrow Nr. 4.



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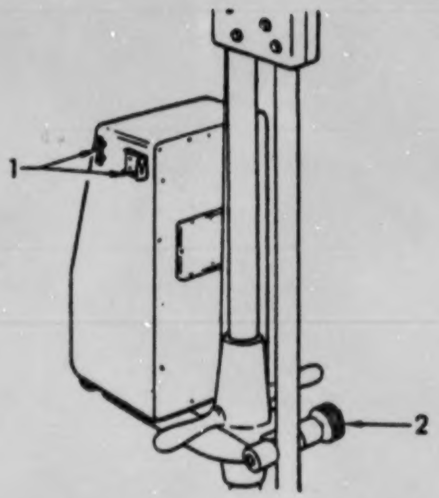
Located immediately behind the tester handles is the aiming screw. When this screw is turned, the entire tester case is rotated to either the right or left. On the upper left side of the tester case is a form of peep sight. Locate these parts in the accompanying illustration.



QUESTIONS 16 and 17.

16. Arrow Nr. 1 in the illustration above points to which of the following listed components?

    a. Candlepower meter.

    b. Tester sight.

    c. Aiming screw.

    d. Viewing window.

17. Arrow Nr. 2 in the above illustration points to which of the following listed components?

    a. Candlepower meter.

    b. Tester sight.

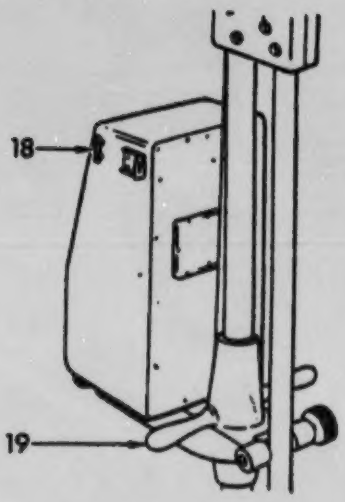
    c. Aiming screw.

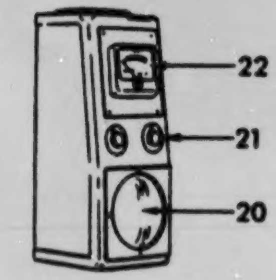
    d. Viewing window.

Frame 12.

QUESTIONS 18 through 22.

Study the illustrations below and locate the numbered items.





Using the below-listed nomenclature, select the correct name for each numbered item in the illustration above. Enter your choice in the appropriately numbered space on the answer sheet for each numbered item shown above.

a. High-low knob.

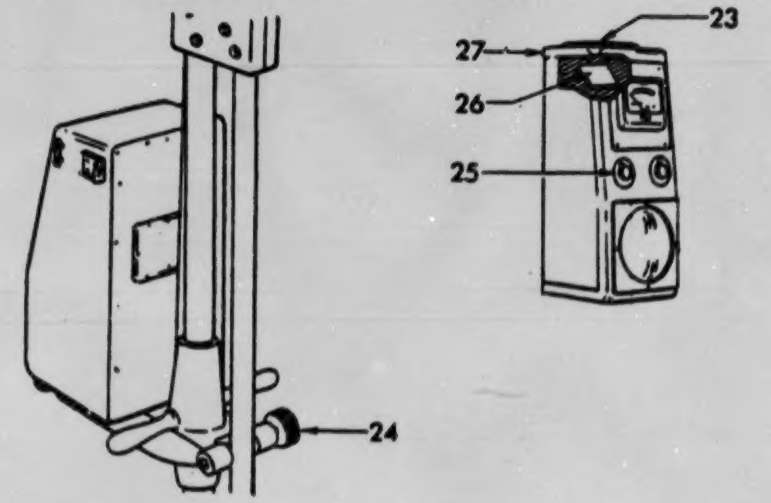
b. Tester lenses.

c. Tester sight.

d. Tester handles.

e. Candlepower meter.

Complete the next five questions as you did the last five.



a. Viewing mirror.

b. Left-right knob.

c. Tester case.

d. Viewing window.

e. Aiming screw.

Frame 14.

The headlight calibration stand consists of a piece of metal tubing on a stand. The tubing has a bracket at the top to hold a flashlight.

QUESTION 28.

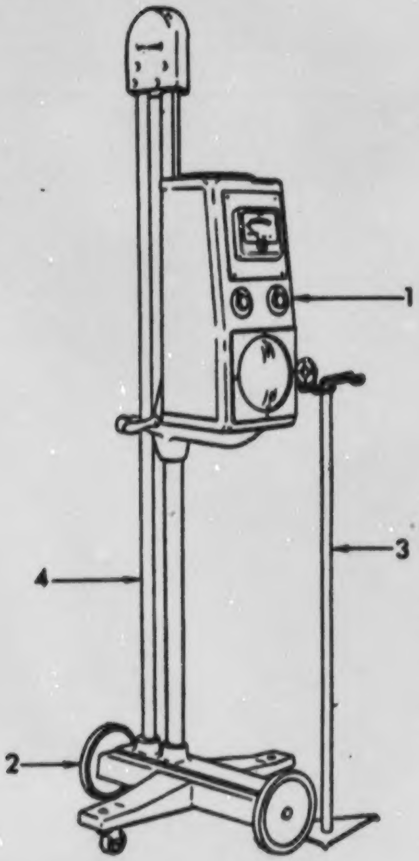
In the accompanying illustration, which arrow indicates the calibration stand?

a. Nr. 1.

b. Nr. 2.

c. Nr. 3.

d. Nr. 4.



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Frame 15.

PART II

WEAVER HEADLIGHT TESTER CHECKLIST

INSTRUCTIONS TO THE STUDENT:

Now that you have completed the instructional package, you are ready to apply that knowledge to the actual equipment. There are a few rules that are necessary to follow as you progress through this checklist.

RULE #1. Follow each step carefully. Complete each step before moving on to the next step.

RULE #2. If, at any time, you find a step too difficult, or you cannot accomplish the task, specific instructions are given within that step for remedial action.

RULE #3. If you cannot complete a step, STOP! Do not proceed until that situation has been cleared up.

RULE #4. YOU are your own supervisor. YOU are responsible for learning the task as outlined in the book. You will be required to perform specific tasks at a later time. Be sure that you know the material before proceeding to a new area.

RULE #5. Do not place any tools or equipment on the tester case at any time.

RULE #6. Do not lean on the vehicle at any time.

RULE #7. Do not abuse the tools or equipment. This equipment cost the Air Force many dollars and you may be held liable for damage to it.

RULE #8. Do not fail to ask a question any time that you are in doubt about any thing.

RULE #9. DO take your time and enjoy your work.

You may now proceed to turn the page and begin this part of the program on Frame 16.

Frame 16.

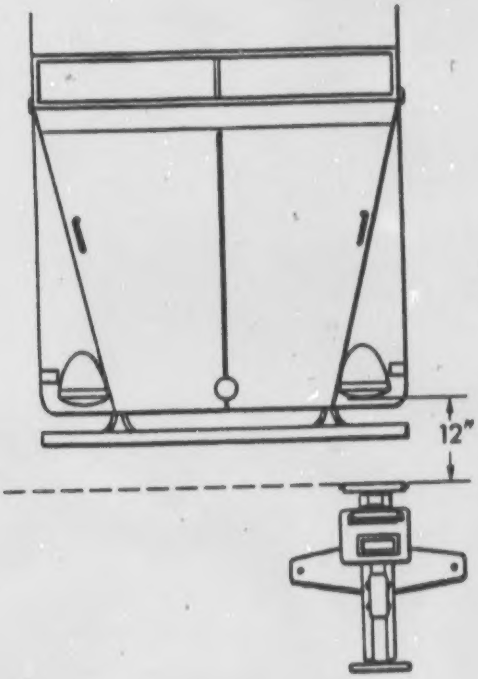
1. Make sure that the vehicle is unloaded except for the normal cargo. Normal cargo includes such items as tire tools, jacks, spare tires, etc.

2. Check the tires for specified pressures and inflate as necessary.

Step #2.

CALIBRATING THE HEADLIGHT TESTER

Position the Weaver Headlight Tester "squarely" in front of the vehicle with the tester lens 12 inches from the center of the left headlight lens (observe the diagram below).



NOTE: Some vehicles equipped with 4 headlights have 2 of the headlights recessed. For calibration purposes, it is necessary that you select the headlight that protrudes (sticks out) the most.

QUESTION 29.

Do you understand this operation?

YES - Good, go on to the next step.

NO - Stop! Do not turn the page until you have accomplished the step described above. As soon as you have completed the task described, you may turn the page and begin the next part of the task.

Frame 18.

Step #3.

Now - Roll the tester slowly, straight across to the right headlight.
STOP - Do not push the tester in toward the right headlight.

When you complete the task outlined above go on to Frame 19.

CAUTION: DO NOT ATTEMPT TO MOVE THE TESTER AT THIS TIME.

Now, measure the distance between the tester lens and the right headlight. Record this measurement on the back side of your answer sheet after item 30.

QUESTIONS 31 and 32.

31. Did you measure from the center of the tester lens to the center of the right headlight lens?

    a. YES - Good, record your measurement as item 31.

    b. NO - Do so now and then record that measurement as item 31.

32. Was your measurement at the right headlight 12 inches?

    a. YES - Proceed to Frame 22.

    b. NO - Turn the page and continue with Frame 20.

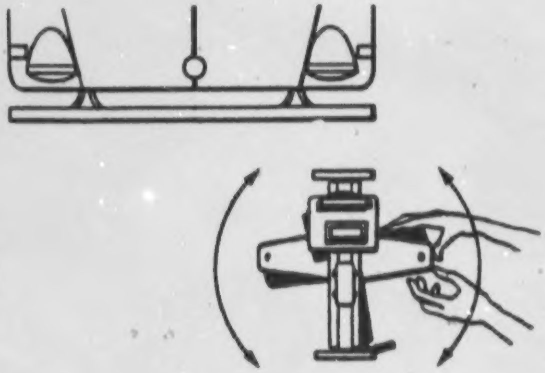
Frame 20.

Step #6.

If your measurement at the right headlight was more than 12 inches, proceed with the task listed in this frame. If the measurement was less than 12 inches, go to Frame 21 immediately.

1. Your measurement was more than 12 inches. Roll the tester slowly and precisely along the parallel line in front of the vehicle until the tester lens is directly in front of the left headlight again.

2. Turn the tester base slightly to the right (approximately 1/2 inch) as indicated in the illustration below.



3. Now, slowly roll the tester along the parallel line until the tester is again in front of the right headlight lens. Measure the distance again.

4. If the tester is still more than 12 inches from the headlight lens, repeat the above procedure (a fraction of an inch at a time) until the tester lens is in position 12 inches from both the right and left headlights.

IMPORTANT: Always make adjustments while the tester is in front of the left headlight.

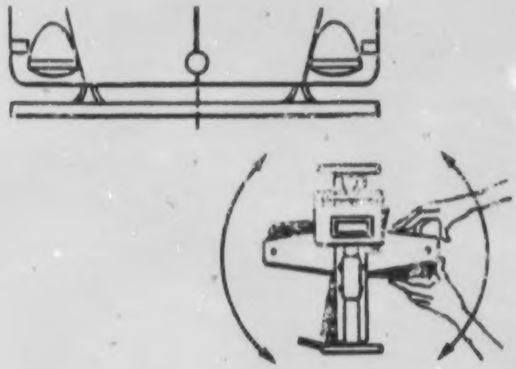
You may now proceed to Frame 22.

Step #7.

Your measurement at the right headlight indicates that the tester lens is less than 12 inches from the headlight lens. FOLLOW THESE DIRECTIONS VERY CAREFULLY.

1. Roll the tester slowly and precisely along the parallel line in front of the vehicle until the tester lens is once again directly in front of the left headlight lens.

2. Turn the tester base to the left slightly (try about 1/2 inch at a time.) Follow the diagram below.



3. Now, roll the tester slowly along the parallel line until the tester lens is directly in front of the right headlight. Measure the distance between the tester lens and the right headlight lens.

4. If the distance is still less than 12 inches, repeat the above procedure (a fraction of an inch at a time) until the tester lens is 12 inches from both right and left headlight lens.

IMPORTANT: Always make your adjustments while the tester is in front of the left headlight.

You may now proceed to Frame 22.

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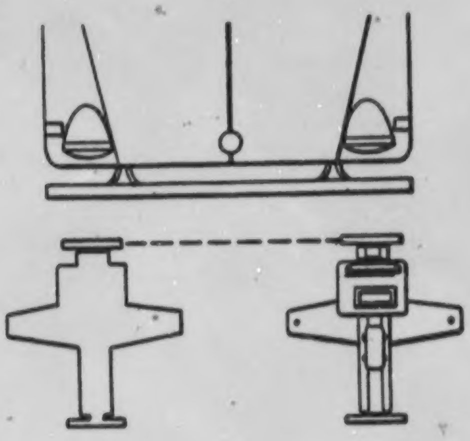
Frame 22.

Step #8.

The tester lens is now positioned exactly 12 inches from the center of both the right and left headlights.



Now that you have completed the first task, you are ready to proceed to the next task.

CAUTION: DO NOT do anything except the item included in one step. Always accomplish an entire step before proceeding to the next step.

You may now go to Frame 23.

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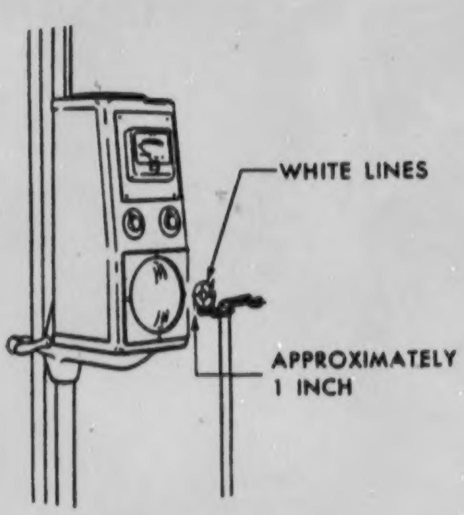
Step #9.

Place the calibrating stand in front of the tester as shown in the illustration below.



NOTE: Observe the white lines (on some stands this line is black) on the circular portion at the top of the calibration stand, and the horizontal white lines at the tester lens.

QUESTION 33.

Are you having any problems?

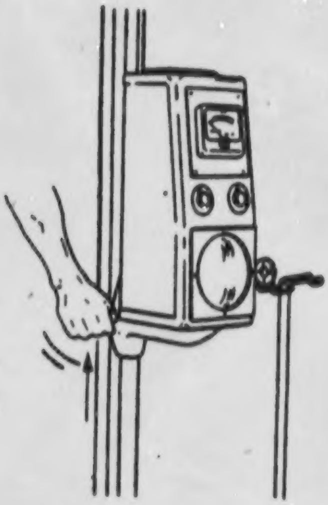
a. YES - Read the NOTE above.

b. NO - Go on to the next frame.

Frame 24.

Step #10.

Carefully grasp the handles on the tester support case and move the tester case up or down until the horizontal white lines at the tester lens are lined up with the white (or black) horizontal lines on the calibration stand. See illustration below.



QUESTION 34.

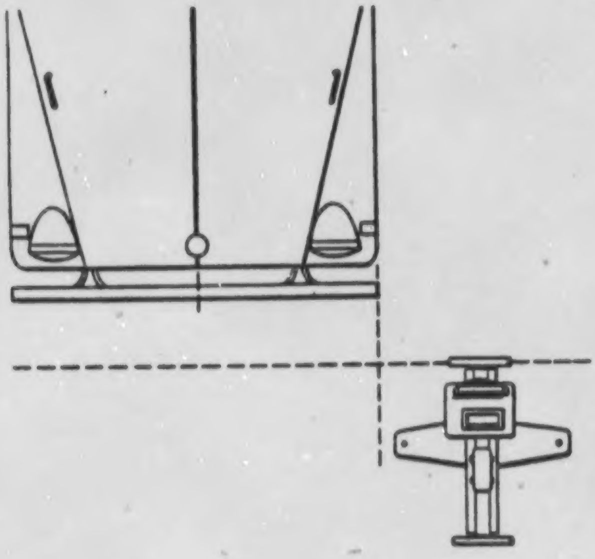
Did you have any difficulty?

a. YES - Consult your instructor.

b. NO - Go on to the next frame.

Step #11.

Carefully roll the tester sideways along the parallel line until the tester is just to the outside of the vehicle. Consult the diagram below. The test stand must clear the vehicle.



NOTE: From now on, handle the tester carefully so as not to move it off its parallel line with the headlights.

QUESTION 35.

Did you accomplish this task satisfactorily?

a. YES - Go on to Frame 26.

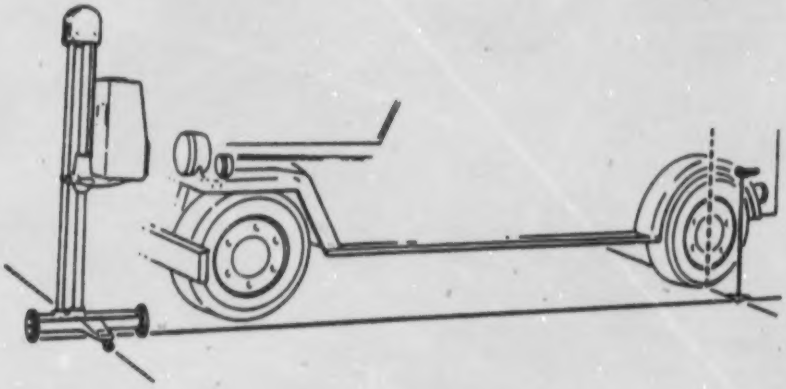
b. NO - Consult the diagram above, then try again. If you are still unable to accomplish this task, notify your instructor.

Frame 26.

Step #12.

CAUTION: DO NOT MOVE THE TESTER.

Place the calibration stand opposite the rear wheel of the vehicle at approximately the same distance from the side of the vehicle as the tester is from the side.



QUESTION 36.

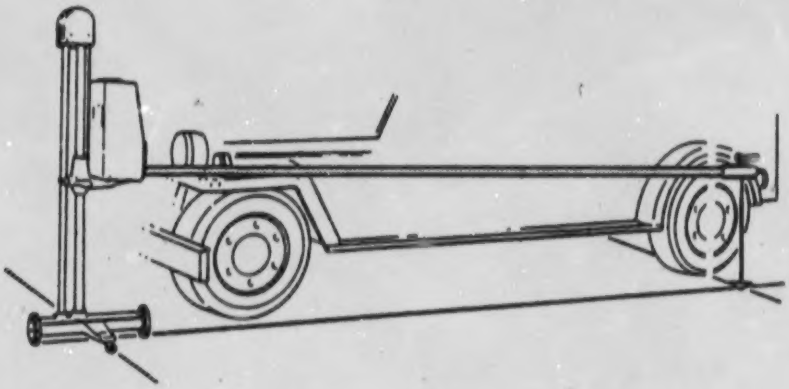
That wasn't hard was it?

a. YES - Take another look at the diagram above and try to figure out what you did wrong. If you can't correct the problem, call your instructor.

b. NO - Proceed to Frame 27.

Step #13.

Place a lighted flashlight on the calibration stand top so that the light shines through the hole where the white line is scribed. Point the beam directly at the tester lens.



QUESTION 37.

Did you turn the flashlight on?

a. YES - Go on to the next frame.

b. NO - Do so now and then go on to the next frame.

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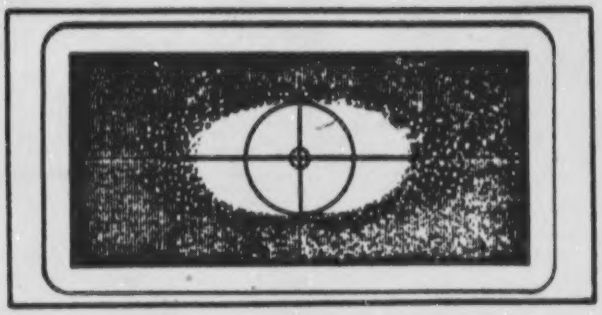
Frame 28.

Step #14.

Look down through the viewing window of the tester, and to the rear and observe the flashlight beam being reflected on the viewing mirror. Move the HIGH-LOW and/or LEFT-RIGHT knobs on the tester slowly until the flashlight beam is well-centered in the large circle on the viewing mirror.



NOTE: Care should be taken not to move the tester at this time.

The operation just performed is compensating for the level of the floor.

QUESTION 38.

Are you having trouble?

a. YES - You had better contact your instructor.

b. NO - Good! Go on to Frame 29.

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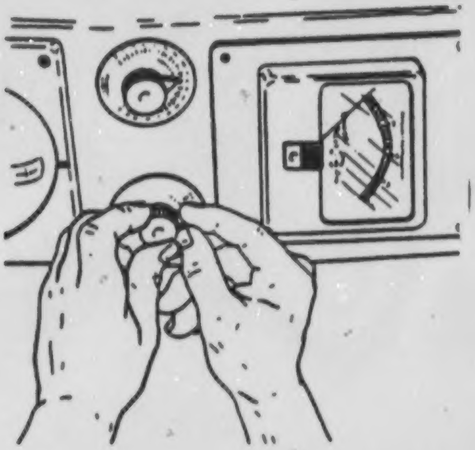
Step #15.

After centering the flashlight beam on the viewing mirror, grasp the HIGH-LOW knob firmly with one hand and without letting the knob turn, move the pointer to the "O" position on the dial. THIS IS A CRITICAL TASK.



NOTE: After you move the pointer to "O", recheck the flashlight beam to make sure that it is still in the center of the viewing mirror.

QUESTION 39.

Was the flashlight beam off-center after you moved the arrow?

a. YES - Return to Frame 28 and start again.

b. NO - Go on to the next frame.

Frame 30.

Let's make a quick review of what you have done so far. You are doing just great. Here is a list of the tasks you have completed.

1st - You positioned the tester lens 12 inches in front of both "high beam" headlights.

2nd - You matched the line on the calibration stand with the line on the tester case (at the lens).

3rd - You centered the flashlight beam in the tester lens after you had set the calibration stand near the rear wheel of the vehicle.

4th - You set the HIGH-LOW arrow to "O" without moving the HIGH-LOW knob.

After you have read the above review, you may go on to Frame 31.

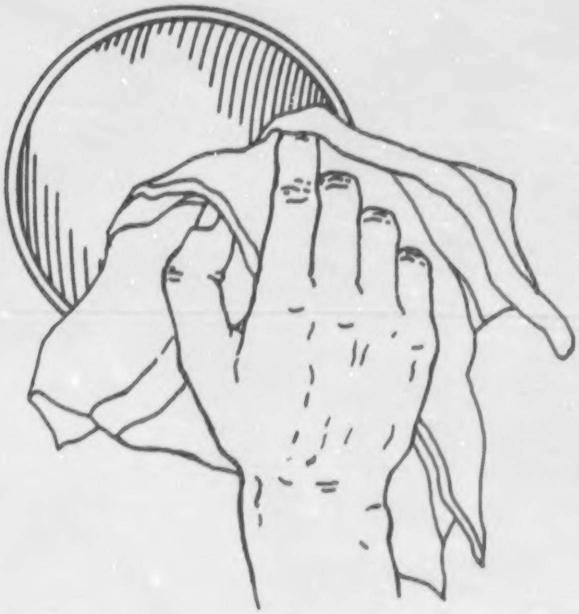
You're doing real well. Take your time and complete the tasks.

Step #17.

PREPARE THE VEHICLE.

NOTE: Turn the flashlight off.

We are now ready to prepare the vehicle for testing. The first thing to do is to obtain a soft cloth and clean all headlights.



Frame 32.

Step #18.

One important thing, of course, is to make sure that all headlights operate. Turn on the headlights. While you are in the vehicle, start the engine and set the throttle at a fast idle. (This last operation may require an adjustment of the idle screw at the carburetor.)

Running the engine at fast idle keeps the battery in a good state of charge and keeps lights at peak performance.

Make sure that all headlights are operating by pressing the dimmer switch. Both "high" and "low" beams must be operating properly.

QUESTION 40.

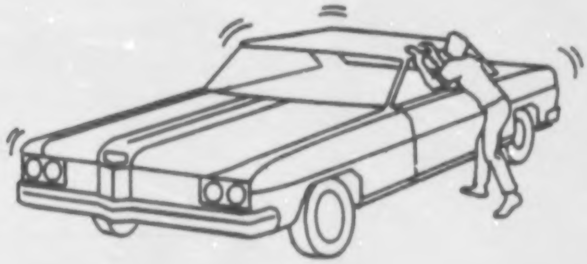
Did all headlights operate?

a. YES - Proceed to Step 19 (just below).

b. NO - Consult your instructor. He will either repair the lights or assign you to another vehicle.

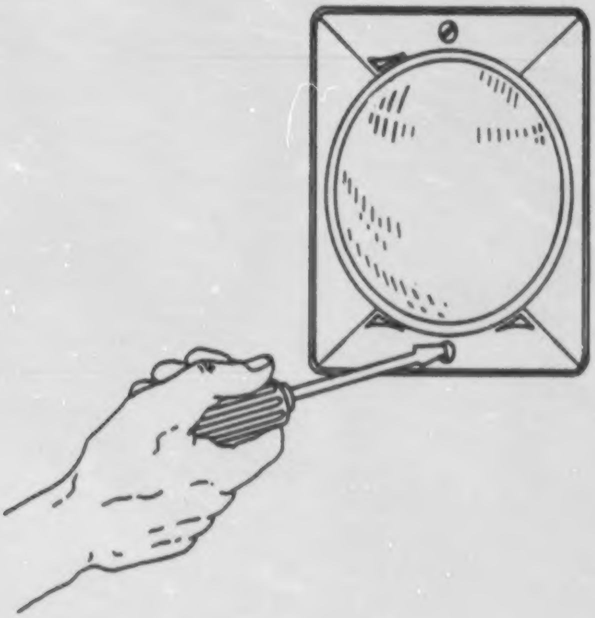
Step #19.

Rock the vehicle sideways to relieve spring set.



Step #20.

Remove the metal rims from around the headlight lens.



QUESTION 41.

Sometimes these screws are troublesome. Did you remove the screws?

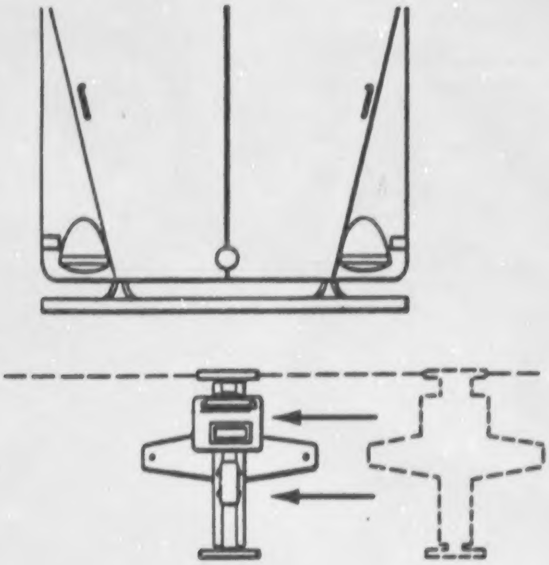
a. YES - Go on to the next frame.

b. NO - Ask your instructor for help.

Frame 34.

Step #21.

Move the tester carefully and slowly along the parallel line in front of the vehicle until the tester is located in the center of the vehicle.



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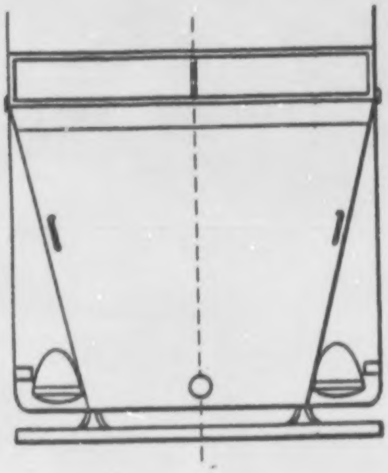
Step #22.

Visualize an imaginary line down the center of the vehicle.

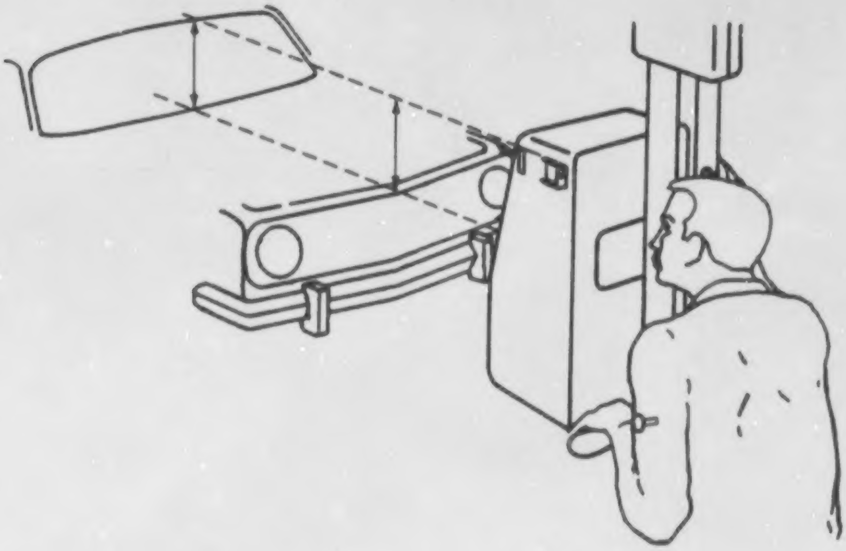
NOTE: If the vehicle hood has a ridge down the center, you may assume that this is the center of the vehicle. If there is no ridge, then you will have to make an imaginary line through the center of the hood, through the center of the windshield, and on through the rest of the vehicle.



Frame 36.

Step #23.

Look through the back sight of the headlight tester until you locate the centerline of the vehicle. Once you have the centerline in focus with the back sight of the tester, turn the aiming screw until the front sight of the tester is in line with the back part and the centerline. THIS OPERATION IS CRITICAL.



QUESTION 42.

Are the back sight and the front sight aligned with the vehicle's centerline?

a. YES - Good, go on to the next frame.

b. NO - Consult your instructor.

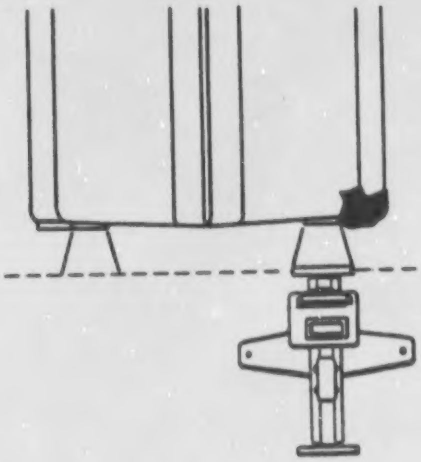
Step #24.

Turn the headlights on "high" beam.

NOTE: If the vehicle is equipped with four headlights, all four will operate with the dimmer switch in the high beam position. However, the inside lights are the high beams. The outside lights operate on either high beam or low beam.

Carefully roll the tester sideways along the parallel line until the tester lens is directly in front of the high beam headlight.

NOTE: If the vehicle is equipped with four headlights, you will have to cover the outside headlight with a dark cloth. Do this now, if necessary.



Frame 38.

Step #25.

Now that you have the tester lens located directly in front of the high beam headlight, you are ready for a critical task. Carefully raise or lower the tester case until the maximum candlepower is indicated on the tester meter.

NOTE: Perform this operation slowly. When the headlight beam is directly in the center of the tester lens the needle on the tester meter will be at its highest point.. That's where you want it right now.

QUESTION 43.

Are you doing everything as directed?

a. YES Go to the next frame immediately.

b. NO You had better ask the instructor for assistance.

Step #26.

Now, roll the tester sideways along the parallel line (back and forth) until maximum candlepower is again located on the tester meter.

NOTE: Roll the tester slowly. You may not have to move the tester more than an inch or so in either direction in order to obtain the highest candlepower indication.

You think that you have the maximum candlepower now, don't you? Let's check and see if you do. Carefully and slowly repeat Steps 25 and 26 to see if you can get a higher candlepower indication.

Now that you have maximum candlepower you may proceed to the next frame.

Frame 40.

Remember the review you had a short while ago?

That review covered the calibration sequence, because you:

a. Positioned the tester lens 12 inches in front of both high beam headlights.

b. Matched the line on the calibration stand with the line on the tester case (at the lens).

c. Centered the flashlight beam in the tester lens after you had located the calibration stand near the rear wheel of the vehicle.

d. Set the HIGH-LOW arrow to "O" without moving the HIGH-LOW knob.

Now, take a look at the things you have completed since the calibration sequence:

a. You cleaned the headlights.

b. You turned on the headlights, checked them, and started the engine and set it for fast idle.

c. You checked for excessive cargo and proper tire inflation.

d. You rocked the vehicle sideways to relieve spring set.

e. You removed the metal rims from the headlights.

f. You squared the tester case by lining it up with the center of the vehicle by turning the aiming screws.

g. You covered the low beam (on a four-headlight vehicle) and set the tester case in front of the high beam headlight. You obtained the maximum candlepower on the meter by moving the tester up, down, right, and left.

After reading the above review, proceed to Frame 41.

Step #27.

Now, turn the HIGH-LOW knob on the tester until the highest candlepower reading is indicated on the tester meter.

CAUTION: Do not put your hand or allow your sleeve to come between the tester lens and the headlight. This action could lower the candlepower indication.

Turn the LEFT-RIGHT knob slowly until the maximum candlepower is indicated on the tester meter.

You should just about have maximum candlepower indicated on the meter. Just to be sure, and this is important, turn both the HIGH-LOW and LEFT-RIGHT knobs, one at a time, slowly until you are sure of having maximum candlepower indication.

CAUTION: DO NOT LEAN ON THE VEHICLE.

QUESTION 44.

Are you having any problems?

a. YES You had better go back and re-execute Frames 37 through 41 again. If this doesn't clear up your problems, check with your instructor.

b. NO Proceed to the next frame.

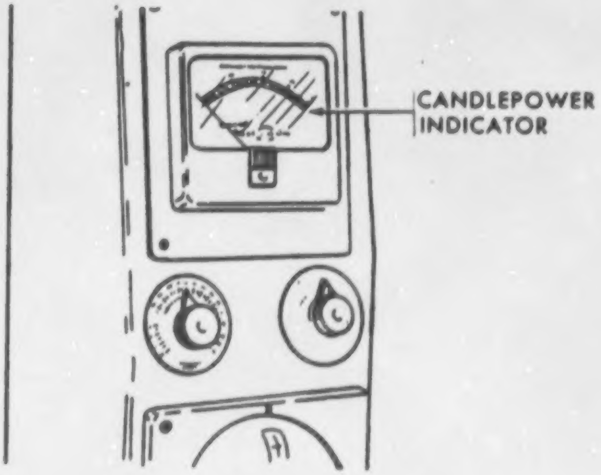
Frame 42.

Step #28.

INTERPRETING CANDLEPOWER INDICATIONS.

Read the candlepower as indicated on the tester meter.

This is the maximum candlepower of the headlight. It is the indication you should get after completing the adjustments described in the next few steps.



NOTE: The meter indicates candlepower in thousands of candlepower and the divisions on the meter indicate "POOR," "GOOD," and "EXCELLENT."

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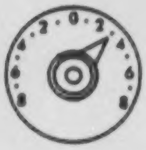
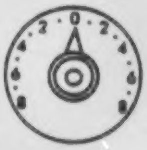
Step #29.

Look at the HIGH-LOW knob.



The position of the HIGH-LOW arrow indicates how much drop or rise (in inches) the headlight beam has in 25 feet. EXAMPLE: If the arrow is pointing to "4" at the right of "O" it means that the headlight beam drops four inches every 25 feet.

Now, look at the LEFT-RIGHT arrow.



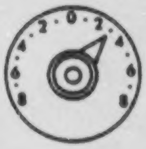
The position of the RIGHT-LEFT arrow indicates the number of inches the headlight is turned right or left at 25 feet.

Frame 44.

Step #30.

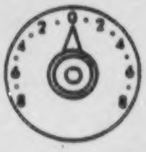
ADJUSTMENTS.

We're ready to make asjustments on the headlights now if they need adjustment. First, set the HIGH-LOW arrow to "3" to the right of "O". This figure is not shown on the scale, so merely set the arrow halfway between "2" and "4".



NOTE: When the headlights are properly adjusted they will have a drop of 3 inches for every 25 feet of headlight projection.

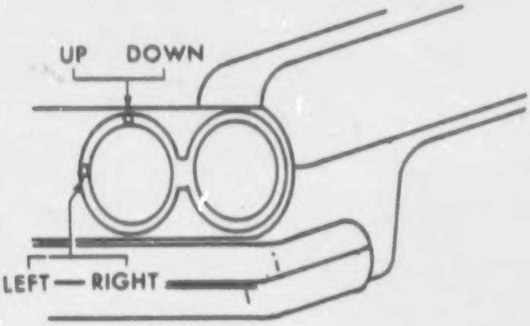
Set the LEFT-RIGHT arrow on "O".



NOTE: Most vehicle operators prefer to have no side angle to their headlights.

Step #31.

Now you are ready to make the necessary adjustments on the headlight. The HIGH-LOW knob is set on "3" and the RIGHT-LEFT knob is set on "O". Raise or lower the headlight until the maximum candlepower indication is obtained. When this is done, adjust the headlights left or right until the maximum candlepower is obtained.



NOTE: After you have completed the task outlined above, you may look into the viewing mirror. The mass of the headlight beam should then be centered in the bulls-eye on the mirror.

You have now completed all assigned tasks on the Weaver Headlight Tester.

Replace the headlight rims, replace all removed cargo, and turn off the headlights and the engine.

Return all tools and equipment to the instructor.

Consult with your instructor to see what is next for you to do.

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PREPARE THE MAN

PROGRAMMED TEXT
3ABR47232-PT-404

8-11

Technical Training

General Purpose Vehicle Mechanic

LIGHTING, SIGNAL, AND WARNING SYSTEMS

31 December 1975

USAF SCHOOL OF APPLIED AEROSPACE SCIENCES
3340th Technical Training Group
Chanute Air Force Base, Illinois

Designed For ATC Course Use

DO NOT USE ON THE JOB

FOREWORD

This programmed text was designed for students enrolled in the General Purpose Vehicle Repairman Course, 3ABR47330. It was validated by students enrolled in that course in 1964 and has proved satisfactory since that time.

OBJECTIVES

Upon completion of this programmed text you will be able to accomplish the following objectives with 90% accuracy.

1. Given three circuits and a list of circuit conditions, match each circuit with the correct condition.
2. Given a diagram showing different pieces of test equipment and a list of test equipment names, match each piece of test equipment with the correct name.
3. Given electrical circuits with a continuity light connected at different points, indicate by each circuit whether the light should be ON or OFF.
4. Given electrical circuits with a voltmeter connected at different points and a list of voltage readings, match the voltage reading to the correct circuit.

Supersedes 3ABR47330-PT-404, 13 May 1970.
OPR: TWS
DISTRIBUTION: X
TWS - 250; TTVGC - 1

Frame 1

As is true in diagnosing any trouble, what the driver states is wrong with the vehicle merely reflects his impressions. For this reason, the first step in troubleshooting is to establish the facts, making the necessary correction where the fault is, before proceeding with the next step in the operation.

A quick analysis of the entire electrical system to isolate individual circuits causing trouble is made by determining if current is available at various points in the main circuits. These tests can all be made from the driver's seat and no equipment is required. The tests used are as follows:

1. Press the horn button (momentarily).
2. Operate the starter switch (momentarily).
3. Turn the ignition switch "ON" (15 seconds).
4. Turn the headlights "ON" (momentarily).

Based on observations made during the four (4) tests made above, furnish your diagnosis for the seven situations set up on Frame 2.

Frame 2

Choose the appropriate word(s) for each of the following questions that make them TRUE statements. Mark a or b on your answer sheet to indicate your choice of answers for each question.

QUESTIONS 1 through 7

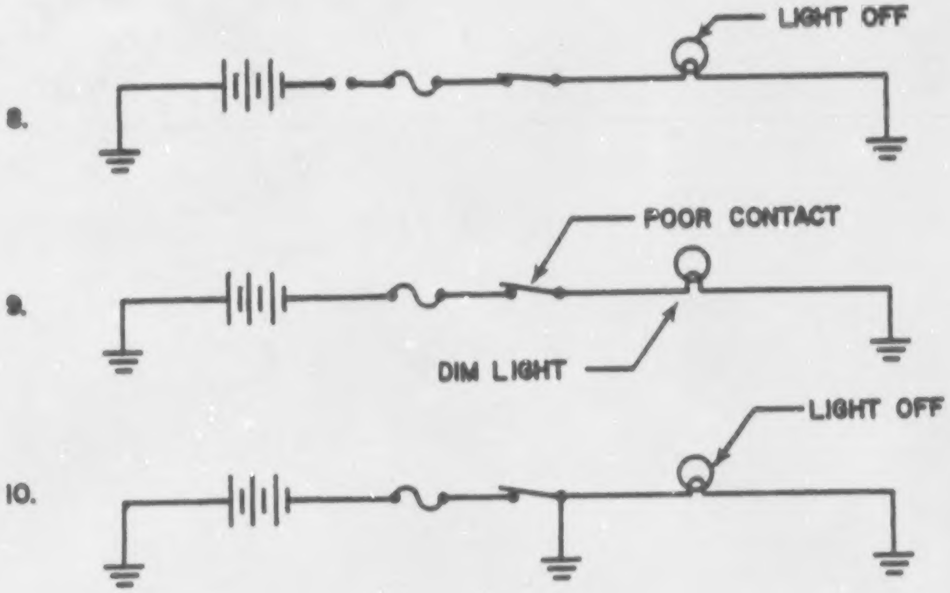
1. If the horn sounds, the battery and battery cables are
   a. OK.
   b. faulty.
2. If the horn does not sound but the starter engages, instruments register, and the lights light, the trouble is in the
   a. light circuit.
   b. horn circuit.
3. If the starter engages the battery, cables, and starter relay are
   a. faulty.
   b. OK.
4. If the starter does not engage, but the horn sounds, the trouble is in the
   a. circuit breaker circuit.
   b. starter circuit.
5. If the instruments register and the lights light, the battery, battery cables, and the circuit breaker are
   a. OK.
   b. faulty.
6. If none of the instruments register and none of the lights light, the trouble is probably in the wire running from the battery to the
   a. starter.
   b. circuit breaker.
7. If none of the instruments register but the lights light, the trouble is either in the main feed wire to the instruments or the
   a. ignition switch.
   b. circuit breaker.

Frame 3

Circuit testing, commonly known as "troubleshooting," is a means of systematically locating faults in an electrical circuit. These faults are usually one of three kinds: (1) Open circuits in which leads or wires are broken, providing no path for current to flow; (2) Shorted circuits in which grounded leads cause current to be returned by short cuts to the source of power; and (3) High resistance circuits in which lights burn dimly and relays chatter, because an insufficient rate of current flows in the circuit. These electrical troubles may develop in the units themselves or in the wiring.

QUESTIONS 8 through 10

Demonstrate your knowledge of circuit conditions by matching the proper condition, from those listed below, to each of the following numbered circuits.



— CONDITIONS —

a. SHORTED CIRCUIT
b. OPEN CIRCUIT
c. HIGH RESISTANCE CIRCUIT

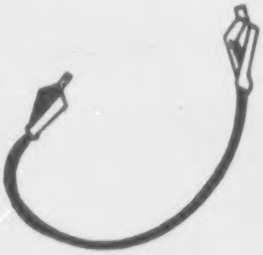
Frame 4

The equipment used in troubleshooting electrical circuits in a vehicle consists of a continuity light, a jumper lead, and a voltmeter. The continuity light consists of a small automotive-type light bulb with two flexible leads connected to the contacts. The jumper lead may be any piece of flexible insulated lead, three to four feet long (with an alligator clip at each end) The voltmeter should have long flexible leads and must be capable of measuring the voltages of the circuits it is to be used on. The voltmeter in the CB-12 volt-amp tester is an excellent instrument to use for this purpose.

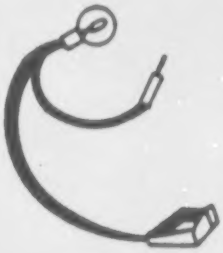
QUESTIONS 11 through 13

Match the proper piece of test equipment, from the lettered items below, to the test equipment names in the numbered items that follow:

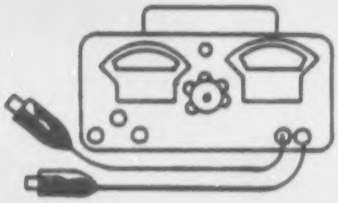
11. Continuity light.
12. Jumper lead.
13. Voltmeter.



a.



b.



c.

Whenever generator or battery voltage is available, the continuity light and the voltmeter can be used in circuit testing, since these sources of power will activate both the continuity light and the voltmeter. The jumper lead is used to provide a test path for power or ground in a circuit or to a unit.

QUESTIONS 14 and 15

Match the proper piece(s) of test equipment to be used, from the lettered items below, to the applications described in the numbered items that follow:

14. To test a live circuit (power "ON").

15. To provide an additional power or ground path in a circuit.

a. Continuity light.

b. Jumper lead.

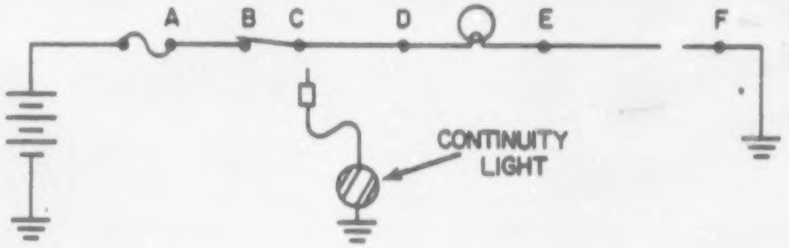
c. Voltmeter.

A circuit in which current flows through all the elements from the source of power and back is said to be continuous or possess continuity. However, if there are opens in the circuit, current may not flow at all; or, if started, may flow through only part of the circuit and directly back to the source. Both shorted and open circuits can be discovered by checking the continuity of a circuit.

Frame 6

A continuity light provides a satisfactory method of checking the continuity of wiring on vehicles. The power for its operation is furnished by the vehicle's storage battery.

The following procedure indicates the steps that may be used for continuity checking with a continuity light in a circuit which consists of a battery, a fuse, a switch, and a lamp.



LAMP OUT - OPEN IN GROUND

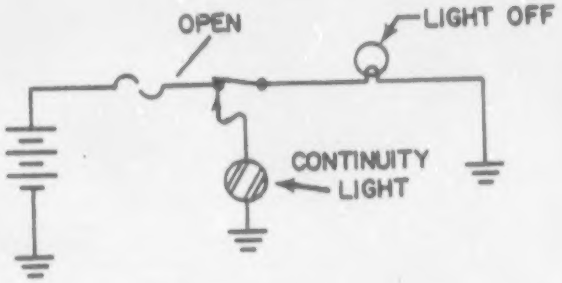
- Continuity Testing With a Continuity Light -

In the circuit shown above, first check the fuse by touching one lead of the continuity light to the load end of the fuse, test point A, and the other lead to ground. If the fuse is good, the continuity light will light. If the fuse is burned out, the continuity light will not light.

If the fuse tests good, the circuit has an open. Then, with one lead of the continuity light connected to ground, move the other lead from test point to test point along the circuit following the diagram as a guide. The first "no light" condition indicates that there is an open in the circuit between the last test point and the present one. The lamp will light at test points A, B, C, D, and E, but it will not light at test point F. Therefore, an open in this circuit is between test points E and F.

QUESTIONS 16 through 18

Study each of the following circuits. Then, choose the appropriate word for each of the following statements to make them TRUE statements.

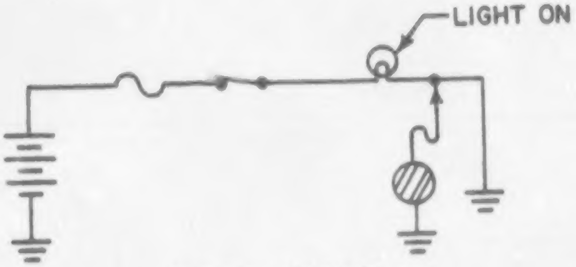

OPEN
LIGHT OFF
CONTINUITY LIGHT

OPEN IN FUSE

The continuity light in this circuit is

a. off.

b. on.

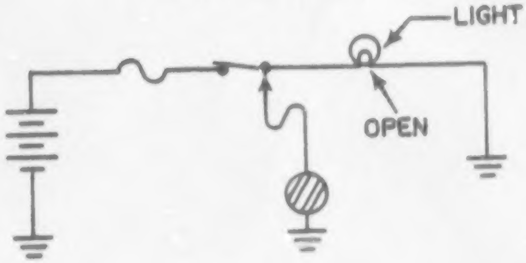


NORMAL CIRCUIT

The continuity light in this circuit is

a. on.

b. off.


LIGHT OFF
OPEN

OPEN IN LIGHT

The continuity light in this circuit is

a. on.

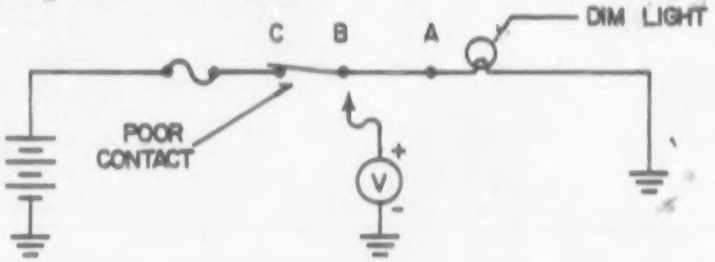
b. off.

Frame 8

A voltmeter with long flexible leads provides a satisfactory method of checking the continuity of the wiring and equipment on vehicles. The voltage to be checked by the voltmeter is furnished by the storage battery of the vehicle.

The procedure for using the voltmeter in troubleshooting is similar to that of using the continuity light. The advantage of using the voltmeter is that losses in voltage because of high resistance in the circuit (drop in voltage) can also be detected.

The following procedure indicates the steps that may be used for circuit testing with a voltmeter.



LAMP DIM - HIGH RESISTANCE IN SWITCH

- Circuit Testing With a Voltmeter -

With the negative (-) clip of the voltmeter connected to ground, move the positive (+) clip from point to point along the circuit, with the power "ON."

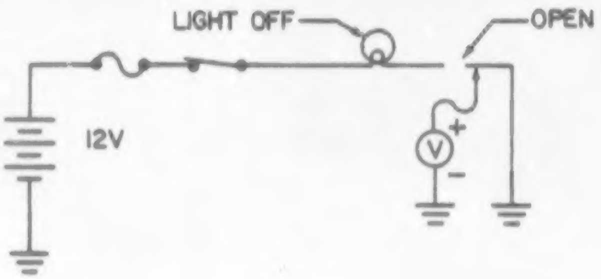
Note: Keep in mind that this procedure is for a negative ground circuit. If you work on a positive ground circuit, you must reverse the leads.

Test each unit and length of wire. The first below normal voltage reading on the voltmeter indicates that there is a high resistance condition between the last point at which the voltage was normal and the point of the below normal indication. In the circuit above, the voltage is low at the light socket, test point A, and at the load side of the switch, test point B. At the power side of the switch test point C, the voltage is normal. Therefore, the high resistance is in the switch contacts.

Frame 9

QUESTIONS 19 through 21

Study each of the following circuits - then, select the correct answer for each of the following statements:


LIGHT OFF
OPEN
12V
V
+
−

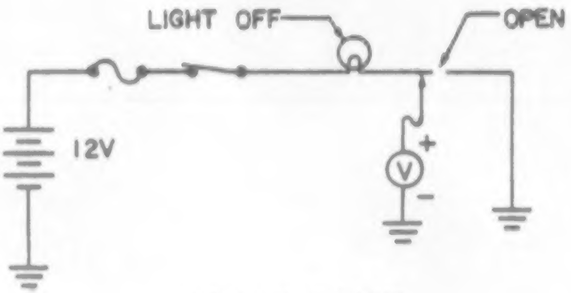
OPEN IN GROUND

The voltmeter in this circuit will read

a. 12 volts.

b. less than 12 volts.

c. zero volts.


LIGHT OFF
OPEN
12V
V
+
−

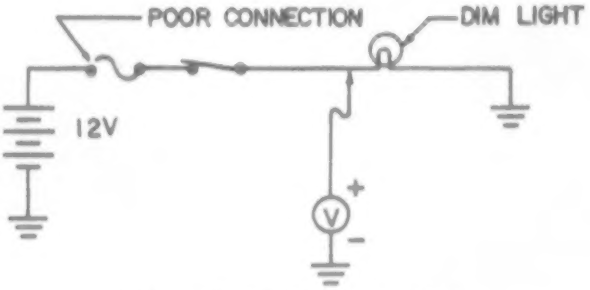
OPEN IN GROUND

The voltmeter in this circuit will read

a. zero volts.

b. 12 volts.

c. less than 12 volts.


POOR CONNECTION
DIM LIGHT
12V
V
+
−

HIGH RESISTANCE AT FUSE

The voltmeter in this circuit will read

a. zero volts.

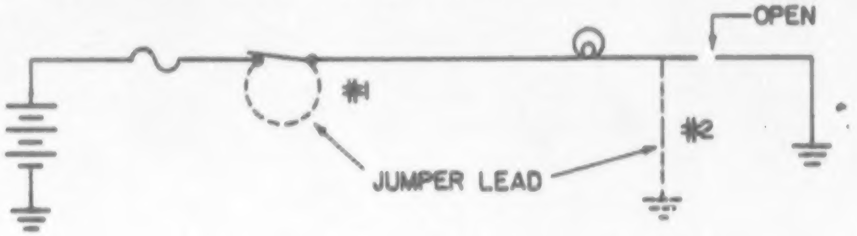
b. 12 volts.

c. less than 12 volts.

Frame 10

A jumper lead is a handy way to provide test paths for power in an electrical circuit. It can be used to provide power to units, to complete ground circuits when normal grounds are open, and to short around suspected units such as relays and switches.

The following procedure indicates the steps that may be used for checking a circuit with a jumper lead.



LIGHT OUT - OPEN IN GROUND

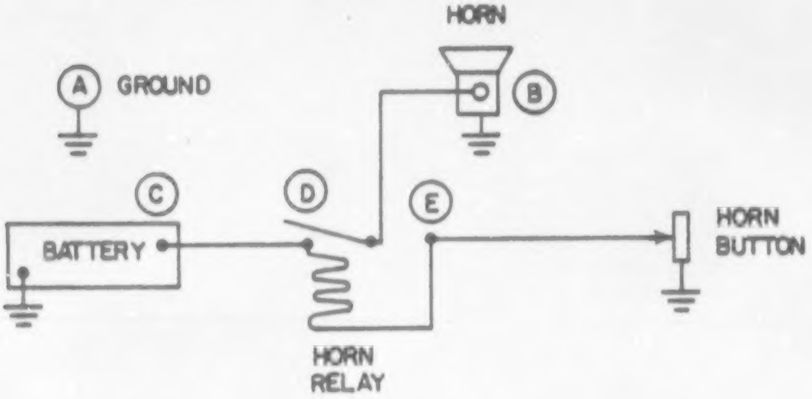
- Circuit Testing With a Jumper Lead -

In the circuit shown above, the fuse, lamp, and battery all check out as being good.

If the switch is suspected of being inoperative, touch one end of the jumper lead to the power side of the switch and the other end to the load side of the switch, as shown in the illustration above by jumper lead #1. If the switch was faulty, the lamp would now have power and would light up. Inasmuch as this did not affect this circuit, it shows that the switch was OK.

The trouble in this circuit is an open ground to the light. If this condition is suspected, the jumper lead is removed from the switch and connected between the light and a source of ground, as shown in the illustration above by jumper #2. This completes the circuit and the lamp will now light. The trouble can be corrected by providing a new ground lead to the lamp or, in an emergency, the present wire could be spliced.

The horn circuit drawn below consists of a battery, a relay, a horn, and a switch (horn button). A relay is used in the circuit in order to reduce the voltage loss. This is done by installing the relay so that the length of wire from the battery to the horn is as short as possible. When the horn button is pressed, a small amount of current necessary to magnetize the relay coil passes through the horn switch and then to ground. The magnetic field created draws the movable contact down to complete the circuit directly from the battery to the horn. The operation of the horn relay is very similar to the operation of the relays in generator regulators.



- Horn Circuit -

QUESTIONS 22 through 24

In checking the horn circuit shown above with a jumper lead, indicate between what lettered points you would "jump" in order to determine the following:

22. To check if the lead from the horn button to the relay is open, jump between points ______ and point ______.
23. To check if the relay is getting power from the battery, jump between points ______ and point ______.
24. To check if the horn will work (blow), jump between points ______ and point ______.

297

Frame 12

Checking a circuit to locate electrical troubles resolves itself into the following general procedures:

1. Check the fuse. Be sure it is the one in the circuit you desire to check.
2. Check the electrical unit itself.
3. If both the fuse and the unit are good, but checking indicates an open or short in the circuit, check the most accessible known points until you locate the trouble.
4. Never guess - locate the trouble in the insulated circuit, the operating unit(s), or the ground circuit before you remove any equipment or wires.

⇩

After completing this part of the training program, return this book with your answer sheet to your instructor. He will assign you a vehicle to troubleshoot.

RESPONSE CONFIRMATION PANEL

Question Number	Correct Answer	Question Number	Correct Answer
1.	a.	13.	c.
2.	b.	14.	a and c.
3.	b.	15.	b.
4.	b.	16.	a.
5.	a.	17.	b.
6.	b.	18.	a.
7.	a.	19.	c.
8.	b.	20.	b.
9.	c.	21.	c.
10.	a.	22.	A and E
11.	b.	23.	C and D
12.	a.	24.	C and B

LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE TWSTI/7Feb 75/ Eason	INSTRUCTOR
COURSE NUMBER 3ABR[redacted] 47232	COURSE TITLE General Purpose Vehicle [redacted]n, Part I Mechanic
BLOCK NUMBER V	BLOCK TITLE Power Trains

LESSON TITLE
Clutches, Standard Transmission , and Power Take-Off

LESSON DURATION

CLASSROOM/Laboratory	XXXXXXXXXX/Complementary	TOTAL
D&D 4 hrs/Perf 5 hrs	2 hrs	11 hrs

POI REFERENCE

PAGE NUMBER	PAGE DATE	PARAGRAPH
27	2 January 1975	1

STS/CTS REFERENCE

NUMBER	DATE
STS473X0	3 September 1974

SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
1. Trainer: 60-2528 2. Trainer: 60-2534 3. Mechanic's Common Hand Tools 4. Special Tools 5. Clutch 6. 3 Spd. Standard Trans. (OVER)	None	None	1. 3ABR47330-SG-501 2. 3ABR47330-PT-501 3. 3ABR47330-PT-501A 4. 3ABR47330-PT-501B 5. T036A2-3-6-2 6. T036A2-3-8-2 7. T036A2-4-17-2 (OVER)

CRITERION OBJECTIVES AND TEACHING STEPS

a. Without references, identify basic facts and terms relative to principles of operation, function, and relationship of power trains and components with 70% accuracy.

b. Provided with technical publications, bench items, tools, and equipment and applying automotive personnel and equipment shop safety, repair or service power trains and components IAW the technical order.

Teaching Steps are Listed in Part II.

EQUIPMENT LOCATED IN LABORATORY

7. Power Take-Off

GRAPHIC AIDS AND UNCLASSIFIED MAT.

8. Film: TFI-4047F
9. Chart: CAFB 67-106
10. " " 74-20
11. " " 67-264
12. " " 67-265
13. " " 67-266
14. " " 67-267
15. " " 67-268
16. " " 67-269

INTRODUCTION

15 Min

1. Attention and Motivation: Every automobile on the road today will require some degree of maintenance and service at one time or another. A conservative estimate will be that about 40% of this maintenance will involve the power train. "Will you be ready?"

2. Review: Your last three blocks of instruction were dedicated to engine construction, operation, support systems and tune-up procedures. Now comes the time to make this power useable at the wheels. We will now go over any question about last night's assignment, 3ABR47330-SG-501, 3ABR47330-PT-501. Grade outside assignment; reteach as necessary.

3. Overview and TIE-IN: Describe the overall purpose, construction and operation of the power train and sequence in which learning process will be developed. (Chart 67-106).

BODY

8 hrs. 30 min.

PRESENTATION:

1. Ref: Para a, Part 1
    - a. Clutch
        - (1) Purpose — Conservation of Utilities & Resources
            - (a) Provides means to connect or disconnect engine and transmission
            - (b) Smooth engagement of power
            - (c) Allows shifting of gears without stopping
        - (2) Location — Chart CAFB 67-106 Cross-cut view: Automobile Chassis
            - (a) Directly behind engine
            - (b) Between engine and Transmission
        - (3) Types
            - (a) Classified by type of springs used in pressure plate
                - 1 Coil spring — Borg & Back, 3 finger
                - 2 Diaphragm spring — GM-vettes
            - (b) Centrifugal operation

(c) Multiple disc — Bikes, automatics

(4) Construction and Operation - CC 74-20

(a) Drive members

1 Flywheel - polished surface — Bolted to crank case hardened bolts

2 Pressure plate

a Bolted to flywheel — Case hardened bolts

b Spring pressure applies the clutch disc to flywheel

c Springs, release lever and cast iron plate part of assembly — Show bench items Clutch assy. components

(b) Driven Member - Clutch Disc

1 Operates between the two drive members

2 Friction facings

a Riveted to metal backing of plate

b Creates friction

c Lining material composed of woven asbestos and cotton fibres reinforced with brass wire segments — Metal linings - high perf. Why brass wire?

3 Splined center hub turns the transmission input shaft

4 hub is flexible on torsion springs to dampen shock of initial engaging

(c) Controls and linkages

1 Mechanical linkage

a pedal

292

b Metal rod transfers pedal movement to clutch housing

2 Hydraulic linkage — What benefits?

a Pedal operates piston in hydraulic cylinder

b Pressure carried to a slave cylinder through lines — Similar to Hyd. brakes

c Slave cylinder operates push rod for release lever

3 Clutch fork (release lever)

a Arm pivoted in housing

b Holds and operates release bearing

c Activated by pedal or slave cylinder linkage

d returned by spring — Why is spring necessary?

4 Release Bearing

a Bearing depresses the pressure plate levers

b Slides on collar over transmission input shaft

c Factory packed bearing — Cannot be repacked

(d) Clutch adjustment (FREE TRAVEL)

1 Free travel-distance bearing travels before contacting release levers — Explain consequences of incorrect adjustment

2 Clearance controlled by either lengthening or shortening control rod

EQUIPMENT LOCATED IN LABORATORY

7. Power Take-Off

GRAPHIC AIDS AND UNCLASSIFIED MAT.

8. Film: TFI-4047F
9. Chart: CAFB 67-106
10. " " 74-20
11. " " 67-264
12. " " 67-265
13. " " 67-266
14. " " 67-267
15. " " 67-268
16. " " 67-269

3 Measurement is made at pedal.

b. Standard Transmission — Chart 67-106

(1) Purpose: To provide a suitable gear ratio between engine and rear axles for various driving conditions — Trn. 60-2528

(a) Selective speeds or ratios that match demands — Show 3 spd. transmission to illustrate components

(b) Provide a neutral position

(c) Provide a reverse gear

(2) Location and types

(a) Located behind engine and clutch

(b) Selective types - 3, 4, or 5 speed

(c) Auxiliary transmission

1 Located behind main transmission

2 Separate shift lever in cab

3 Gives additional gear ratios — EXPLAIN

(3) Construction and Operation

(a) Vented Case — WHY?

(b) Shafts

1 Input or clutch shaft

2 Main or output shaft

3 Countershaft

4 Reverse idler shaft

(c) Types of gears

1 Spur

2 Helical — Show types & advantages of each

(d) Bearings: to support and align shafts in case, and gears on shafts

(e) Bushings: can be used in some areas in lieu of bearing

(f) Thrust plates: used to separate gears and gears from case — WHY?

(g) Synchronizer unit: device used to equalize speed of two moving gears or shafts to facilitate smooth engagement — Show & explain

(h) Control Cover

1 Located on top or side of transmission case

2 Houses shaft and shifting forks — Also detents

3 Connected to shift lever

(i) Operation — Film: TFI 4047-F

1 Input and counter shafts in constant mesh — Charts 67-106
264
265

2 Mainshaft is output
266
267

3 Reverse idler in constant mesh with countershaft
268
269

c. Power take-off (PTO) — Trainer:60-2534

(1) Purpose: Attachment to transmission which provides rotating force to power auxiliary equipment — Trucks & Tractors

(2) Construction and Operation — Show power take-off

(a) Sliding gear which will mesh with countershaft

(b) PTO output shaft connects to auxiliary component, I.E. winches, pumps

(c) Gear is engaged or disengaged from countershaft by linkage from cab of vehicle

Usually cable

(3) Types

(a) Single Gear

(b) Reproduction

(c) Double drive

APPLICATION:

1. Ref para b, part 1
Common handtools
Bench items

"Special Tools"
Dial indicator
TO 36A2-3-6-2
TO 36A2-3-8-2
TO 36A2-4-17-2

STRESS SAFETY

EVALUATION:

1. Why do we need a transmission?
2. Define the term gear.
3. What drives the transmission input shaft?
4. What are the major clutch components?
5. How is the pressure plate attached to flywheel?
6. What are the main purposes of the clutch?
7. How is clutch free travel adjustment made?
8. What are the most common types of clutches?
9. What holds and operates the release bearing?
10. What keeps the bearing away from the pressure plate when clutch is released?
11. Name the 4 shafts in a transmission.
12. What is a synchronizer?
13. What drives the countershaft?
14. What is the PTO used for?
15. Where is the PTO mounted?
16. Where would you find an auxiliary transmission?

17. What type gears are most common?

18. What two types of linkages are used
 in clutch controls?

CONCLUSION 15 Min.

SUMMARY AND REMOTIVATION:

1. In order to transmit power smoothly from the engine to the transmission we use the clutch. The clutch disc then drives the transmission input shaft which drives other gears to eventually give desired gear ratio to the rear axles. An attachment to the transmission, called a PTO will allow us to use the gears to drive auxiliary equipment.

ASSIGNMENT AND CLOSURE: CTT POI Para 2a 2 Hrs. - PT 501A 501B

1. Review today's lesson and principles in preparation for removal, inspection, repair and adjustments to be covered in tomorrow's lesson, and read 3ABR47330-SG-502, and answer review questions at the end. Conservation of utilities and resources.

LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE TWSTI /7 Feb 75/	INSTRUCTOR
COURSE NUMBER 3ABR[redacted] 47232	COURSE TITLE General Purpose Vehicle Mechanic [redacted], Part I
BLOCK NUMBER V	BLOCK TITLE Power Trains

LESSON TITLE
Clutch and Transmission Removal and Replacement

LESSON DURATION

CLASSROOM/Laboratory D&D 1.5 hrs/Perf 4.5 hrs	LABORATORY /Complementary 2 hrs	TOTAL 8 hrs

POI REFERENCE

PAGE NUMBER 28	PAGE DATE 2 January 1975	PARAGRAPH 2

STS/CTS REFERENCE

NUMBER STS473X0	DATE 3 September 1974

SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
1. Vehicles 2. Mechanics Common Hand Tools 3. Special Tools 4. Transmission Jacks	None	None	1. 3ABR47330-SG-502 2. T036A2-3-6-2 3. T036A2-3-8-2 4. T036A2-4-17-2 5. Chart CC74-20

CRITERION OBJECTIVES AND TEACHING STEPS

a. Supplied with tools and equipment, technical orders, vehicles, and observing automotive personnel and equipment shop safety, remove, repair, and replace clutch and transmission IAW the technical publication.

b. Given vehicles, tools, and equipment, technical publications, and practicing automotive personnel and equipment shop safety, use visual and operational means to check the clutch and transmission IAW the technical order.

Teaching Steps are Listed in Part II.

ATC FORM AUG 72 770

☆ GPO: 1972 779-306/53

INTRODUCTION

15 Min.

1. Attention and Motivation: Knowing how a certain component is constructed, how it operates and where it is heated, is really only part of the program. We must also be aware of how to determine malfunctions, procedures to remove and replace these components and how to make necessary repairs.

2. Review: We have studied the components of the clutch assembly and operation of clutch and transmission to transmit engine torque to rear wheels. Now comes the time to perform maintenance, keep in mind Safety is our first concern. At this time I will answer any questions about last night's assignment 3ABR47330-SG-502, 3ABR47330-PT-501A and 3ABR47330-PT-501B. Grade outside assignment: Reteach as necessary.

BODY

5 Hrs. 30 Min.

PRESENTATION:

1. Ref: Para a, Part 1

    a. Shop safety

        (1) Secure raised vehicle

        Assign students to their respective vehicles

            (a) Place stands under frame rails or axle housing

            (b) If raising only front of vehicle block rear wheels

        (2) Wear goggles under vehicle

        Stress safety with use of goggles

        (3) Keep doors closed

        (4) Always stand creepers up when not in use

        (5) Disconnect battery cable

        (6) Keep fingers away from moving parts of jack

        (7) Do not leave tools underfoot (especially round tools)

        (3) Wipe up oil or grease spills immediately

    b. Troubleshooting clutch operation

(1) Slippage	
(a) Oil on disc	
1 Rear Engine oil seal	
2 Front transmission	
3 Cracked case	
(b) Worn friction lining	
(c) Improper free travel	
(d) Defective pressure plate	
(2) Clutch chatters	Very annoying
(a) Weak springs in pressure plate	
(b) Heat cracked plate of flywheel	
(c) Loose facing on disc	
(d) Worn facing on disc	
(3) Clutch Grabs	Dangerous-Veh Can jump forward suddenly
(a) Defective linkage	
(b) Defective pressure plate	
(c) Broken torque springs in disc	
(d) Oil or grease spots on facing	
c Clutch and transmission removal and replacement	Explain procedures TO 36A2-3-6-2
(1) Raise & Secure vehicles	TO 36A2-3-8-2
(2) Drain transmission lubricant	TO 36A2-4-17-2
(3) Disconnect shifting linkages	
(4) Disconnect clutch linkage	
(5) Remove propeller (Drive) shaft	

- (a) tape U-joint cups
- (b) container for bolts & nuts

(6) disconnect speedometer cable

(7) remove cross member or mount

- (a) may be necessary to support engine
- (b) May require removal of hand brace cables

(8) Remove attaching bolts

(9) Remove transmission assembly

Use transmission jack where required

- (a) use a jack for larger transmissions

(NOTE)
4 spds. cars & trucks automatics

(10) Remove clutch inspection cover from clutch (bell) housing

- (a) Some vehicles require removal of entire clutch housing

(11) Remove clutch release bearing

(12) Remove pressure plate and clutch disc

- (a) Mark P. Plate flywheel for proper reassembly

Why?

- (b) Keep case hardened belts

Explain why?

(13) Remove flywheel only if inspection warrants refacing or replacement

- (a) Check starter ring gear
- (b) Check pilot bearing (smoothness)
  - 1 Located in end of crankshaft
  - 2 Supports and aligns transmission input shaft

"Special Tools"

(14) Torque flywheel to crankshaft bolts

Students will use torque wrench IAW TO procedures

(15) Replace in reverse procedure:

  (a) Before tightening pressure plate bolts perform clutch alignment

Why?

  (b) Aligning clutch

    1 Clutch alignment is aligning clutch splines, transmission shaft and pilot bearing

    2 Performed with

      a Clutch alignment tool

      b Pilot shaft (old transmission shaft)

      c Dummy shaft, shaft which is machined to transmission input shaft measurements

    3 Insert tool through hub on disc and into pilot bearing

    4 Leave tool in place and begin to torque pressure plate bolts

    5 When tool is removed clutch disc will be stationary

d. Inspection of parts

(1) Clutch disc

  (a) Worn facing

  (b) Loose or missing rivets

Warped plate

  (c) Broken torque springs

  (d) Chipped or twisted spline in hub

(2) Pressure plate

(a) Weak or broken apply springs	Cracked or warped cover
(b) Worn or unlevel release levers	Check attaching holes
(c) Heat crack in plate	
(d) Grooves in plate	
(3) Clutch Release Bearing	Also check before disassembly
(a) Smoothness of operation	
(b) Fit of bearing carrier on input shaft collar	
(c) Smoothness of bearing face	
(d) Cannot be repacked, must be replaced if defective	
(4) Release mechanism	
(a) Worn at pivot points	Bent or binding linkage
(b) Out of alignment	
(c) Free travel adjustment	
(d) Return spring tension	
(5) Transmission	
(a) Check gear wear	Synchronizers
(b) Seals and gaskets	
(c) Shifter mechanism operation	Worn or twisted forks
(d) Input and output shaft bearings or bushings	
(e) Refill transmission with applicable lubricant, (after the transmission is installed)	What is usual lube?

APPLICATION:

1. Ref: Para b, Part 1	Vehicles, Common Hand Tools. Special tools Torque Wrench

EVALUATION:

1. Were would jack stands be placed to support vehicle?

2. What could cause clutch slippage?

3. If you found gear oil on the clutch disc what would you check?

4. What causes a clutch to chatter on engagement?

5. Why should the pressure plate and flywheel be marked before disassembling?

6. Define clutch alignment.

7. What could be used to perform alignment?

8. What is clutch free travel?

9. How do you adjust free travel?

10. What must be done if release bearing is rough and dry of lubricant?

11. What checks shouls be made on the transmission during clutch replacement?

12. Discoloring and cracks on the pressure plate and flywheel surfaces indicate ___________?

13. What could cause the gears to grind when shifting from 2nd to 3rd?

14. Briefly describe clutch alignment procedures.

15. When would it become necessary to support the engine during transmission removal?

CONCLUSION

15 Min

SUMMARY AND REMOTIVATION:

1. Safety, proper troubleshooting procedures and using proper manuals are the prerequisite of any job performance. How well you perform your duties and the quantity of work performed are usually two of the major areas used in the rating process of job performance evaluation.

ASSIGNMENT AND CLOSURE: CTT POI Para 3a 2 hrs

1. Complete 3ABR47330-SG-503, 3ABR47330-PT-503 for tomorrow's lesson. Appraisal on today's materials and jobs will be given before class tomorrow. Conservation of utilities & resources.

LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE TWSTI /7 Feb 75/	INSTRUCTOR
COURSE NUMBER 3ABR4[redacted] 47232	COURSE TITLE General Purpose Vehicle [redacted] Mechanic, Part I
BLOCK NUMBER V	BLOCK TITLE Power Trains

LESSON TITLE
Transfer Case, Propeller Shafts, Center Bearings and Universal Joints

LESSON DURATION

CLASSROOM /Laboratory O&D 3 Hrs	[illegible] /Complementary 2 Hrs	TOTAL 5 Hrs

POI REFERENCE

PAGE NUMBER 29	PAGE DATE 2 January 1975	PARAGRAPH 3

STS/CTS REFERENCE

NUMBER STS473X0	DATE 3 September 1974

SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
1. Trainer: 60-2533 2. Trainer: 61-2829 3. Trainer: 59-2448 4. Transfer Case 5. Sprag Unit 6. Propeller shafts 7. Center bearings 8. Universal joints	None	None	1. 3ABR47330-SG-503 2. 3ABR47330-PT-503 3. T036A2-5-2-22 4. T036A2-5-2-62 5. Chart: CAFB 67-106 6. Chart: CAFB 74-10

CRITERION OBJECTIVES AND TEACHING STEPS

a. Without reference, identify terms and basic facts relative to principles of operation, function, and relationship of transfer case, propeller shafts, center bearings, and universal joints with 70% accuracy.

Teaching Steps are Listed in Part II.

ATC FORM AUG 72 770

☆ GPO: 1972 779-386/33

INTRODUCTION

15 Min

1. Attention and Motivation: Explain to students the need to know of how to maintain special vehicles, e.g. tactical vehicles and 4 wheel drive recreation type vehicles, also trucks with tandem rear axles.

2. Review: In previous blocks you were taught how the engine develops power and how to keep it and accessory systems operational and in previous lesson in our block we've learned how it is effectively transmitted through the clutch, transmission and to rear wheels. Are there any questions about last night's assignment 3ABR47330-PT-503, 3ABR47330-SG-503. Grade outside assignment; reteach as necessary.

3. Overview and TIE-IN: We are concerned with a component called a transfer case, it is deisgned to transfer power from a straight line so it can be redirected to the front wheels and/or an extra (tandem) rear axle. Also we will be discussing items which allow delivery of power at an angle, the shafts use to carry torque from gear cases to drive axles.

BODY

2 Hrs 30 Min

1. Ref: Para a, Part 1

   a. Transfer case assemblies

      (1) Purpose

         (a) Increase traction and lower gear ratio

         For boondock driving

         (b) Provide power to all driving wheels

         Trainer:60-2533
         61-2829

      (2) Location

         (a) Behind transmission and bolted to the frame

         Crossmember

         (b) Attached to the rear of the transmission on some vehicles

            1 M 38 jeep

            2 M 151 Mutt Ford

            3 IHC Scout, Ford Bronco and Chev. Blazer

      (3) Construction

         (a) Gear train similar to standard transmission

1 Bearing preload-adjusted by shims	
2 Speedometer is driven by output shaft	
(b) Could have one of two reductions and speeds	
(c) Manual transfer case engages front wheels by a lever in the cab	
(d) Automatic transfer case engages front wheels automatically when rear wheels loose traction	Explain benefits sprag unit Show sprag unit
b. Sprag units	
(1) Purpose	
(a) Allows rotation in one direction only add free wheels in the other	Automatic transfer case Show transfer case
(b) A form of overrunning clutch	
(2) Location - Inside the transfer case on the front output shaft	Remember sprag unit for auto trans.
c. Propeller Shafts	
(1) Purpose - Means of delivering power to driving axles and auxiliary equipment	Driveshaft Chart:67-106
(2) Location	
(a) Connects transmission to differential	Balanced when manufactured show weights
(b) Connects power takeoff to auxiliary equipment	
(3) Construction and types	
(a) Torque tube, solid or arm	Old type
1 Enclosed shaft	
(b) Hotchkiss or tublar	Chart:67-106
1 Open type	

d. Slip joints

- (1) Purpose - to permit the propeller shaft to change effective length

  Why?

- (2) Location - On the transmission and/or the transfer case end of the propeller shaft
- (3) Construction - A male and female spline, grease seal, and lubrication fitting
- (4) Balance of propeller shaft and slip joint
  - (a) Aligning arrows
  - (b) Master spline
  - (c) Yokes in the same plane

e. Universal joints

Chart:67-106

- (1) Purpose - To transmit power at an angle

  Show U joints

- (2) Location - On each end of propeller shaft and/or slip joint
- (3) Types
  - (a) General
    - 1 Most common type
    - 2 Used on all M-Series
  - (b) Bal-trunion-Used on older Chrysler production drive shafts
- (4) Construction of general

  Chart:CC-74-10

  - (a) Journal or cross

    Trainer: 59-2448

  - (b) Needle bearings
  - (c) Cups

    Fit in driveshaft yokes

  - (d) Snap rings and/or U-bolts

    Inside or outside snap rings

  - (e) Grease seals (usually cork)

    Neoprene

(f) Grease fittings (zerts)	Optional
f. Center bearings	Also explain pillow block
(1) Purpose - To support and align two or more propeller shafts and	Show center bearings Long wheelbase veh.
(2) Location - Mounted in rubber between two propeller shafts and bolted to the frame or cross members	Use TOs to illustrate TO36A2-5-2-22 TO36A2-5-2-62
(3) Construction	
(a) Sealed type bearing that must be replaced when it gets noisy	
(b) Rubber insulation supports bearing	

APPLICATION: Interspersed throughout lesson.

EVALUATION:

1. What is the purpose of the transfer case assembly?
2. What is the purpose of the sprag unit in the transfer case?
3. Where in the transfer case assembly is the sprag unit located?
4. What is the purpose for the universal joint?
5. Why should universal yokes always be installed in the same plane?
6. What is the purpose of a center bearing?
7. Name two types of propeller shafts.
3. What is the purpose of a slip joint and where is it located?
9. What part must always be replaced when disassembling a universal joint?
10. How should a universal joint be lubricated?

CONCLUSION

15 Min

SUMMARY AND REMOTIVATION:

1. Transfer case allows power to be transmitted to all driving axles. Sprag units allow power to flow in one direction, free wheels in the other direction. Propeller shafts deliver power to differentials and auxiliary equipment. Center bearings support two or more drive shafts. Universal joints allow power to be transmitted at an angle.

ASSIGNMENT AND CLOSURE: CTT POI Para 4a 2 hrs.

1. Read study pip 3ABR47330-PT-504A, 3ABR47330-SG-504. Review today's notes and be prepared for a daily appraisal. Conservation of utilities and resources.

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LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE TWSTI/7 Feb 75/	INSTRUCTOR
COURSE NUMBER 3ABR[redacted] 47232	COURSE TITLE General Purpose Vehicle Mechanic [redacted], Part I
BLOCK NUMBER V	BLOCK TITLE Power Trains

LESSON TITLE
Conventional and Anti-Spin Differentials, Front and Rear Driving Axles

LESSON DURATION

CLASSROOM/Laboratory D&D 6 hrs/Perf 6 hrs	XXXXXXXXXX/Complementary 4 hrs	TOTAL 16 hrs

POI REFERENCE

PAGE NUMBER 30	PAGE DATE 2 January 1975	PARAGRAPH 4

STS/CTS REFERENCE

NUMBER STS473X0	DATE 3 September 1974

SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
1. Trainer: 55-0744 2. Trainer: 66-3291 3. Trainer: 59-2431 4. Vehicles 5. Mechanic's Common Hand Tools 6. Special Tools 7. Dial Indicator	None	None	1. 3ABR47330-PT-504 2. 3ABR47330-PT-504A 3. 3ABR47330-WB-504 4. 3ABR47330-SG-504 5. T036A-1-411 6. T036A2-5-22 7. T036A2-5-2-62 8. Chart:CAFB 74-13
(OVER)			(OVER)

CRITERION OBJECTIVES AND TEACHING STEPS

a. Without references, identify basic facts and terms relative to principles of operation, function, and relationship of conventional and anti-spin differentials, front and rear driving axles with 70% accuracy.

b. Supplied with bench items, tools, and equipment, technical publications, and using automotive personnel and equipment shop safety, repair or service conventional a and anti-spin differentials, front and rear driving axles IAW the technical order.

c. Provided with tools and equipment, technical orders, bench items, and applying automotive personnel and equipment shop safety, use visual, operational means and test equipment to check conventional and anti-spin differentials, front and rear driving axles IAW technical publications.

Teaching Steps are Listed in Part II.

EQUIPMENT LOCATED
IN LABORATORY

8. Front-Driving
   Axle Assy.
9. Conventional Diff.
   Assy.
10. Anti-spin diff.
   Assy.

GRAPHIC AIDS AND
UNCLASSIFIED MAT.

9. Chart:CAFB 67-274
10. " " 67-272
11. " " 74-14
12. " " 74-15
13. " " 74-17
14. " " 74-125
15. " " 74-18
16. " " 74-16
17. " " 74-19
18. " " 67-106

INTRODUCTION 15 Min

1. Attention and Motivation: We are gradually getting nearer our goal of understanding what causes the automobile to move. There is still more to be analyzed and understand, for example, how is the power changed from lateral rotation of the propeller shaft to the horizontal drive required at the wheels?

2. Review: Thus far we've completed our flow of power as follows: Flywheel, to clutch, thru gear ratios in transmission, to a transfer case if required for front drive axles and through U Joint and propeller shaft to the - Differential and Drive Axles. Is there any question about last night's assignment 3ABR47330-PT0504A, 3ABR47330-SG-504.
Grade outside assignment: Reteach as necessary.

3. Overview: The next lesson, today and tomorrow, deals with the differential, both conventional and anti-spin and the front and rear drive axles.

BODY 11 Hrs 30 Min

PRESENTATION:

1. Ref: Para a, part 1.

   a. Differential Assembly (Conventioal)

      (1) Purpose: Mechanism which will permit axles to turn at different speeds and transmit power from drive shaft to the drive axles — When?

      (2) Location: Within a carrier case mounted in the axle housing — Chart #67-106 Vented Housing

      (3) Construction and operation — CC74-16

         (a) Carrier assembly

            1 Housing for differential gears

            2 Mounted in axle housing on roller bearings with retainer caps — Tapered Rollers

            3 Bearing caps are threaded to accomodate adjusting nuts

(b) Differential gears	Trainer #55-0744
1 Side gears (2), commonly called axle gears, are splined to axles	Charts #67-274
2 Pinion or spider gears (2 or 4), mounted on pins or cross shaft. Rotate only on turns	
3 Pinion to side gear clearance is controlled by shims	
(c) Final Drive Gears	Matched Set
1 Drive Pinion - transmits torque of propeller shaft into differential housing	Explain Ratios
2 Ring Gear - Bolted or riveted to differential carrier assy., driven by drive pinion	
(d) Types of final drive assemblies	Chart #67-272
1 Worm gear - used on heavy uipment and some auxiliary equipment	
2 Hypoid - most common on automobiles, very strong and operates quietly pinion and ring gear mesh at bottom	Chart CC74-13 Compare with old spiral bevel
3 Double Reduction - two gear reductions, one output speed	
4 Dual ratio - changeable output ratio	2 spd. rear axle
5 Power divider - mechanism used with tandem rear axles to divide driving effort	Yellow IH tractor

(e) Operation	Trainer #55-0744
1 Turning	
a The inner wheel is automatically slowed down on a turn (road scrub)	
b Axle (side) gear slows down with respect to differential case speed	Why?
c Case forces pinions (spider) gear to rotate along inner axle gear	
d This will cause outer axle gear to be advanced equivalent to differential speed - faster than inner wheel speed	
e Example: Ring gear makes 4 revolutions to drive inner 1 revolution - outer wheel will rotate 7 times	What one wheel loses the other one gains
2 Straight forward	
a Differential ring gear speed is equivalent to combination of both wheels	
b Pinions are not rotating on axis	
c Pinions lock all components causing differential case to turn as 1 unit	
(f) Check and adjust final drive gears	

1 Ring gear runout	What is Run-out?
a Use dial indicator	
b Mount with plunger halfway depressed on backside at ring gear	Why?
c Zero indicator gauge	
d Rotate ring gear one revolution while observing + and/or - reading on gauge	
e Adding + and - readings will give total runout	
f Compare to mfgs. spec.	
g Excessive runout would constitute replacement of ring gear and drive pinion	Why replace both?
2 Backlash check and adjustment	What is backlash?
a Mount dial indicator with plunger on face of ring gear tooth	
b Move ring gear until a tooth is in contact with pinion drive	
c Zero dial indicator	
d Move ring gear until it contacts the next pinion gear tooth (must hold pinion shaft from turning)	
e Reading on gauge will be backlash, clearance	

between tooth on pinion and tooth on ring gear. Compare to mfg. spec.

f Adjustment of clearance (backlash) is accomplished by changing position of ring gear in relationship to drive pinion

g To increase backlash, the ring gear would be moved away from the pinion

h To decrease backlash, the ring gear would be moved toward the pinion

i Movement and adjustment controlled by threaded ring nuts or shims between carrier and housing

Explain
Special tools such as:
Spanner wrench
Differential spreader

j Pinion seal, retains grease in differential where pinion shaft enters carrier housing

(g) Rear driving axles

1 Semi-floating

Chart CC74-14

a Weight of a auto is supported on bearing pressed on axle shaft

Trainer #66-3291

b Brake drum and hub are attached to flange on axle shaft, or by a spline and woodruff key

c Most common on automobiles and 1/2 ton pick-up trucks

2 Full floating	Charts CC74-15 CC74-19
a Axle shaft supports no weight	
b Wheel bearings in hub support axle housing	Similar to front wheels
c Axle shaft can be removed without jacking vehicle	Trainer #59-2431
d Used on 3/4 ton trucks and larger	Why?
b. Differential Assembly (anti-spin)	
(1) Purpose: to supply driving force to wheel with best traction surface	Posi-traction
(2) Located in rear axle housing, mounted on bearings	Chart #67-106 Tapered Rollers
(3) Construction and operation	
(a) Component Parts	Chart CC74-17
1 Differential case	
a Flange half	
b Button half	
2 Bellville spring plates	
3 Clutch friction discs	
4 Clutch friction plates	
5 Bevel side (axle) gears	
6 Side gear rings	
7 Bevel pinion (spider) gears	
8 Pinion mate cross shaft	

(b) Operation

1 Crosspin movement engages or disengages clutch to allow for one wheel to free wheel on corners, or to supply torque to wheel with best traction

Friction & Traction vs Torque

2 Straight forward or backward operation is same as convential

3 On turns clutch would be engaged to inner wheel, therefore, allowing the outer wheel to overrun

c. Front driving axles

(1) Purpose: to supply more traction for climbing or operation on rough terrain

Show Front Driving Axle Assy - "Bench Item" Low Bay

(2) Location: mounted under front of vehicle bolted to springs

(3) Construction and operation

(a) "Banjo" housing of pressed steel

(b) Vented to allow for heat expansion of air to escape

(c) Spherical ends of housing to accomodate steering knuckles

(d) Moveable steering knuckles

1 Ends and knuckles covered by dust seals

(e) Axle shafts

Chart CC74-125

1 Two piece axle shaft connected with a special universal joint

2 Full floating type shaft

3 Attaches to a hub by a splined driving flange and bolts

(f) Constant velocity U-Joint

1 Used front drive axle shaft to allow for turning

CC74-18

2 Types of U-Joints

Explain type used on larger American Pass. Cars

- a Raeppa - Italian design
- b Bendix - Wiess - German design
- c Tracta - G. I. design
- d Carden - U. S. commercial design

3 Hub is mounted on axle spindle with bearings

- a Bearing cups pressed into hub
- b Bearing slides over spindle
- c Bearing preloaded by adjustable nut

END OF DAY SUMMARY

SUMMARY

1. To summarize the day's lesson which dealt with differentials and front and rear drive axles, we will have a short question and answer period.

a. What prohibits removing full floating front drive axle without jacking vehicle?

b. How are backlash adjustments accomplished?

c. What is required in replacement of the axle bearing on a semi-floating axle shaft?

d. A chipped or broken pinion gear would be heard when?

e On a fron drive axle what must be removed to gain access to wheel bearing adjusting/ retainer nuts?

f. What protective equipment is worn while working under a vehicle?

g. What would cause blue or brown discoloration of differential gears and bearings?

h. If the pinion gear meshes with the ring gear at the bottom we have what type of differential?

ASSIGNMENT CTT POI Para 5a 2 Hrs

1. Tomorrow's activity will consist mostly of applying what we have learned today. In the lab area you will be expected to dismantle front and rear drive axles, check and adjust the differential and reassemble the components. Review today's notes and complete 3ABR47330-PT-504.

Conservation of Utilities & Resources

INTRODUCTION TO NEW DAY'S WORK

1. Understanding how a component is constructed, where it is located, and how it works doesn't really help much if you cannot remove, repair and adjust these components.

2. Because there are rotating gears, torque being transmitted and metal parts in contact with each other certain wear tolerances have to be maintained, worn or broken parts replaced and such items as seals and gaskets kept from leaking. Review and grade outside assignment; reteach as needed.

3. Today we are going to disassemble, inspect, repair and adjust differentials, front drive axles and rear drive axles.

APPLICATION:

	TO 36A-1-411
1. Ref: Para b, c, part 1.	
a. Removal procedures	TO 36A2-5-22
(1) Raise and secure vehicle	TO 36A2-5-2-62
(a) Jackstand under axle housing or frame	ENFORCE SAFETY!!! Vehicles Complete 3ABR47330-WB-504
(b) Do not get under unsecured vehicle	
(c) Wear goggles under vehicle	Use mechanic's common hand tools
(2) Drain Lubricant	Use "Bench Items" 1. Front Driving Axle Assy. 2. Conventional Differential Assy. 3. Anti-spin Differential Assy.
(a) Observe for metal filings	
(3) Remove propeller shaft	To illustrate the requirements for maintenance on these units.
(4) Remove wheels and brake drums	
(5) Remove brake backing plate	
(a) Rear axle (semi-floating) - this is also axle shaft retainer	
(b) Some rear axles have retaining clips within differential housing	Remove rear cover
(c) Front axles - this also constitutes removing spindle	
(6) Carefully remove axle shafts	
(a) Front axle - also C. V. U-Joint	
(7) Remove nuts from carrier attaching bolts	

(8) Remove carrier from housing	"Special tools" Differential spreader
(9) Visually inspect components for:	
(a) Worn or twisted splines on axle shafts	
(b) Axle bearings	
(c) Discolored carrier bearings and cups	What causes discoloration?
(d) Worn or chipped spider and axle gears	
(e) Worn final drive gears	
(f) Worn pinion shaft splines and yoke	
(g) Front drive axle - determine serviceability of C. V. U-Joint	
(h) Pinion and axle shaft seals	
b. Repair and adjustment procedures	
(1) Differential (front or rear)	
(a) Check pinion depth and tooth contact	Use white or red Lead Paint IAW TO
(b) Check ring gear runout	Dial indicator
(c) Check backlash	"Special tool" Spanner wrench
(2) Rear axle shafts	
(a) Pressed bearings	
(b) Retainer plate gasket	
(c) Axle shaft seal (in housing)	

(3) Front drive axle

- (a) Bushing in housing
- (b) C. V. U-Joint
    - 1 Handpack with grease upon assembly
    - 2 Check U-Joint for smoothness of operation
- (c) Spindle housing gasket

c Reinstall in reverse procedure of removing

EVALUATION:

1. How would you secure a raised vehicle?
2. What would be the course of action if the ring gear runout proved to be in excess of mfgs. spec.?
3. What would be the most obvious difference between a front and rear axle shaft?
4. What transmits turning force of the front axle shaft to the hub?
5. What is the difference between a full-floating axle and a semi-floating axle?
6. How would you classify a front-drive axle?
7. Where does the front drive axle derive its power from?
8. How do you change the amount of backlash?
9. What lubrication is required when installing C. V. U-Joints?

CONCLUSION 15 Min

SUMMARY AND REMOTIVATION:

1. A differential is used to drive the rear wheels at different speeds as required during turning operations. Anti-spin differentials use a series of clutches to direct the power to the wheel with the best traction surface. Vehicles designed for off highway use, usually are equipped with a driving axle in front for added traction.

2. Referring back to the power plant, clutch, transmission and transfer case we now see a complete picture by knowing about the differentials, axles and drive wheels, our power trains are now complete.

ASSIGNMENT AND CLOSURE: CTT POI Para 5a 2 hrs

1. Starting with tomorrow's lesson, SG & WB 505, we start studying an itme which is increasingly becoming more popular on sedans and pick-ups, the automatic transmission. Conservation of utilities & resources.

2. Now is the time to begin considering the fact, you'll soon be expected to be able to assist in repairs of any auto. Principle remains the same.

LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE TWSTI /7 Feb 75/ Eason	INSTRUCTOR
COURSE NUMBER 3ABR[redacted] 47232	COURSE TITLE General Purpose Vehicle Mechanic [redacted], Part I
BLOCK NUMBER V	BLOCK TITLE Power Trains
LESSON TITLE Principles of Automatic Transmissions	

LESSON DURATION

CLASSROOM /Laboratory D&D 6 hrs	XXXXXXXXX/Complementary 2 hrs	TOTAL 8 hrs

POI REFERENCE

PAGE NUMBER 31	PAGE DATE 2 January 1975	PARAGRAPH 5

STS/CTS REFERENCE

NUMBER STS473X0	DATE 3 September 1974

SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
1. Trainer: 59-2469 2. Bench Items, Misc.	None	None	1. 3ABR47330-SG-505 2. 3ABR47330-PT-505

CRITERION OBJECTIVES AND TEACHING STEPS

a. Without references, identify basic facts and terms relative to terminology, planetary gears and hydraulic principles of automatic transmissions. Students will apply them to selected functions and operations of a simple two speed automatic transmissions with 70% accuracy.

Teaching Steps are Listed in Part II.

INTRODUCTION 15 Min

1. Attention and Motivation: Using a startling statement, or an amusing anecdote make the student aware of the need to know the principles set forth in the upcoming lesson. Gain the students incentive by using the fact that approximately 80% of new cars are equipped with automatic transmissions.

2. Review: Relate to overall need of transmissions in terms of gear reduction and variation of gear ratios. We will now go over any questions about last night's assignment 3ABR47330-SG-505.

3. Overview: Briefly describe the use of planetary gears, their advantages, and how they give different gear ratios required within transmission.

BODY 5 Hrs 30 Min

PRESENTATION:

1. Ref: Para a, part 1.
    - a. Basic Principles of Planetary Gears
        - (1) Terms
            - (a) Torque - twisting force
            - (b) Reduction - torque increase, speed decrease
            - (c) Direct drive - 1 to 1 gear ratio
            - (d) Neutral - no power be transmitted
            - (e) Reactionary - member of gear set which is held to transmit power
        - (2) Simple Planetary Gearset Components — Trainer #59-2469
            - (a) Sun or center gear
            - (b) Planet or pinion gears (and carrier)

(c) Ring or internal gear

(3) Operation of planetary gears — Trainer #59-2469

(a) Reduction Drives

1 Maximum Reduction — Demonstrate
input - sun gear
reactionary - ring gear
output - planet carrier

2 Minimum Reduction
input - ring gear
reactionary - sun gear
output - planet carrier

3 Reverse Reduction
input - sun gear
reactionary - planet carrier
output - ring gear

(b) Direct Drive

1 Lock any two members together

2 Drive two members at same speed in same direction

(4) Advantages

(a) Constant mesh — Explain each

(b) More tooth contact

(c) One common center

(d) Less strain on case

(e) Lend easily to hydraulic control

2 Locate and identify components or planetary gear hydraulic control — Ensure that all students have the flow schematic from 3ABR47330-PT-505

units and drive mechanisms using transmission trainer and bench items. Trace hydraulic oil flow schematic using 3ABR 47330-PT-505, using Pascals Law of Hydraulic Principles

a. Hydraulic Principles & Control Units

(1) Pascal's Law and Principles

(a) Force is equal to area of piston times P. S. I.

(b) Pressure in a closed system is equal in all directions

(c) Motion can be transmitted by liquids

(d) Liquids cannot be compressed under ordinary circumstances

(2) Hydraulic Control Units	"Misc. Bench Items"
(a) Oil Pump	Show Pump
1 Creates pressure	Positive Displacement
2 Engine driven	Gear or rotor
3 Located on front of case	
(b) Pressure Regulator Valve	Illustrate Location of Pressure Regulator
1 Control pump output and pressure	
2 Gives mainline pressure	
(c) Manual Control Valve	
1 Selects range of operation	Explain
2 Controlled by shift lever	

(d) Throttle Valve

"Misc. Bench Item"
Show throttle valve

1 Delays upshift

2 Controlled by accelerator linkage or vacuum modulator

3 Meters pressure according to engine speed

(e) Automatic Shifter Valve

1 Controls application of bands and clutches (automatic upshift)

2 Is opened and closed by pressure from governor or throttle valve and spring

(f) Governor

1 Causes upshift

2 Driven by output shaft

3 Meters pressure according to road speed

(g) Valve Control Body

"Misc. Bench Item"
Show valve body

1 Houses hydraulic control valves - i.e. pressure regulator valve, manual valve, automatic shifter valve

2 Usually located inside the transmission case

(h) Servo

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1 Hydraulic cylinder used to apply bands

2 Hydraulic applied - spring released

3 Converts hydraulic pressure to mechanical force

(i) Bands

1 Friction lined band used to hold one member reactionary for reduction

2 Applied by servo

(j) Friction Clutches

1 Multiple disc

2 Applied by hydraulic piston released by spring pressure

3 Used to lock two members together for direct drive

(3) Actuating and Shifting Controls

(a) Neutral (engine running - not moving)

Simple two speed

1 Pressure to regulator

2 Regulator to manual valve

3 Regulator to governor

(b) Low range - (moving slowly)

1 Servo applying band

2 Throttle valve delaying upshift

3 Slight governor pressure to shifter valve

(c) High Range (Direct Drive)

1 Governor pressure increase to overcome throttle pressure

2 Shifter valve opens to release band and apply clutch

(d) Closed throttle downshift

1 Governor pressure decreases IAW road speed

2 Throttle pressure and spring close shifter valve

3 Clutch is released and band reapplied

(e) Forced downshift (passing gear)

1 Movement of accelerator causes throttle valve to open fully

2 Throttle valve pressure overcomes governor pressure causes shift valve to close

Pass out copies of 3ABR47330

3 Clutch is released and band applied

CONCLUSION 15 Min

SUMMARY AND REMOTIVATION

1. Simple planetary gear sets, consisting of a ring gear, sun gear, and planetary carrier, are used to obtain various gear ratios. Reduction or torque increase is obtained by holding one member reactionary and driving another, while direct drive is obtained by locking two members together. To hold one member, we apply a band with a servo, to lock two members we apply a clutch with a hydraulic piston. Servos and hydraulic pistons are actuated by hydraulic pressure created by the oil pump. The pressure is regulated

by the pressure regulator valve and distributed to various components and valves according to the speed or range the vehicle is operating. (Conduct a short question and answer period).

ASSIGNMENT AND CLOSURE CTT POI Para 6a 3ABR47330-SG-506 2 hrs

LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE TWSTI/7 Feb 75/ Eam	INSTRUCTOR
COURSE NUMBER 3ABR[redacted] 47232	COURSE TITLE General Purpose Vehicle Mechanic [redacted]n, Part I
BLOCK NUMBER V	BLOCK TITLE Power Trains

LESSON TITLE Mechanical Operation and Disassembly of Torque-Elite Transmissions and Selected Components

LESSON DURATION

CLASSROOM /Laboratory	xxxxxxxxx/Complementary	TOTAL
D&D 3.5 hrs/Perf 2.5 hrs	2 hrs	8 hrs

POI REFERENCE

PAGE NUMBER	PAGE DATE	PARAGRAPH
32	2 January 1975	6

STS/CTS REFERENCE

NUMBER	DATE
473X0	3 September 1974

SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
1. Bench Item Torque Flite Transmissions 2. Mechanic's Common Hand Tools 3. Special Tools	None	None	1. 3ABR47330-SG-506 2. T036A2-5-14-2 3. Chart CC74-126 4. " CAFB73-20 5. " " 73-22 6. " " 73-23 7. " " 73-24 8. " " 73-25 9. " " 73-26

CRITERION OBJECTIVES AND TEACHING STEPS

a. Without references, identify basic facts and terms relative to the principles of operation of torque converters and planetary gear trains and provided with questions the students will select the response that identifies selected principles of operations of torque converters and torqueflite transmissions with 70% accuracy.

b. Provided with tools, equipment, & bench items, while adhering to appropriate safety practices, disassemble torque flite transmission IAW appropriate technical publications.

Teaching Steps are Listed in Part II.

ATC FORM AUG 72 770

GPO 1972 779-366/23

INTRODUCTION 15 Min

1. Now that we are aware the types of drives, design of simple planetary gears, and how they are controlled through the use of hydraulic components, let's begin relating principles to specific transmissions. Today we will be concerned with Chrysler Corporation's Torqueflite transmission. Review student accomplishment of 3ABR47330-SG-506 and correct any incorrect responses.

2. In the previous lesson we discussed the use of planetary gearsets to get reduction, forward and reverse, and direct drive. Reduction, which gives us a torque increase, to get the vehicle moving, and once we have reached a cruising or speed fast enough to keep the vehicle moving we will need direct drive. Conduct appraisals of assigned study materials. Test and grade outside assignment: Reteach as necessary.

3. The discussion portion of this lesson will center on how the torque converter functions, the components and construction of the Torqueflite, which utilizes the Simpson design planetary gearset, and finally the operation of the transmision.

BODY 5 Hrs 30 Min

PRESENTATION:

1. Ref: Para A, part 1.
    - a. Torque Converter
        - (1) Location and purpose
            - (a) Bolted to engine flywheel — Flexplate
            - (b) Takes place of clutch
            - (c) Adds weight to flywheel
            - (d) Multiplies torque
            - (e) Reduces number of speeds required — Explain
        - (2) Types
            - (a) Demountable or split
            - (b) Welded
        - (3) Component Parts
            - (a) Impeller - pumping unit driven by engine

(b) Turbine - driven member which is splined to transmission input shaft	
(c) Stator - redirects fluid flow	"Bench Item" Sprag unit
(4) Phases of operation	
(a) Clutch Phase	
1 At idle speed	Veh. stopped, Trans. in gear
2 Very little oil flow	
(b) Torque Multiplication Phase	
1 During acceleration	Chart CC 74-126
2 Stator locks against engine rotation	Redirects fluid
3 Cause vortex (redirected) oil flow	
(c) Fluid Coupling Phase	
1 At cruising speeds	
2 Impeller and turbine speeds are equal, stator is freewheeling	What causes stator to freewheel
3 Causes rotary oil flow	
(5) Torque Converter Malfunctions	
(a) Stator fails to lock on acceleration	
1 Engine seems overloaded	
2 No torque multiplication	
3 Cruising remains normal	
(b) Stator fails to unlock at cruising	337
1 Acceleration would be normal	

2 Unable to maintain cruising speed	
(c) Converter shelled out	
1 Caused by loose or broken vanes in turbine or impeller	
2 Excessive slippage	During Acceleration
3 Extremely noisy	At Idle
b. Planetary Gearing (Simpson Design)	
(1) Two simple sets with one sun gear common to both sets	Torqueflite
(2) Front planetary gearset	
(a) Front ring gear is the drive member	
(b) Front planet carrier in the driven member attached to the output shaft	
(c) Sun gear is the reactionary member	
(3) Rear planetary gear set	
(a) Sun gear is a drive member	
(b) Rear ring gear is the driven member and is attached to the output shaft	
(c) Rear planet carrier is the reactionary member	
c. Planetary Controls	Varies according to manufacturer of trans.
(1) Front clutch	
(2) Rear clutch	
(3) Front band (kickdown)	
(4) Rear band (low-reverse)	
(5) Overrunning clutch (sprag unit)	

d. Operation

(1) Neutral Chart #73-20

(a) Input shaft turns the front clutch hub & rear clutch drum

(b) No clutches applied, no drive to planetary gear sets

(2) Park

(a) Output shaft is locked to case by the parking pawl

(b) With engine running, operation is same as neutral

(3) 1st speed (Drive Range) Chart #73-22

(a) Rear clutch is applied, which connects input shaft to the front ring gear

(b) Front planet carrier is held by output shaft

(c) Front planet pinions turn on their axis and drive the sun gear opposite of input

(d) Sun gear drives the rear planetary pinions in the same direction as input

(e) Rear planet carrier is held by the overrunning clutch

(f) Rear planetary pinions must drive rear ring gear and output shaft in same direction as input

(4) 1st Speed (manual low) Chart #73-23

(a) Rear band is applied and holds rear planet carrier

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(b) Power flow same as 1st speed drive range

(c) Planet carrier cannot rotate either way which provides for engine braking

(5) 2nd Speed — Chart #73-24

(a) Rear clutch and front band are applied

(b) Rear clutch locks input to front ring gear

(c) Front band holds front clutch housing, driving sheel, and front sun gear

(d) Front planet carrier is forced to walk around the stationary sun gear and drive the output shaft

(e) Rear planet carrier idles in direction of engine rotation (allowed by overrunning clutch)

(6) 3rd Speed (Direct Drive) — Chart #73-25

(a) Rear clutch and front clutch are applied at the same time front band is released

(b) Rear clutch locks input to front ring gear and front clutch locks input to the front sun gear

(c) Since two members of the front gearset are being driven in the same direction at the same speed, the entire gear train is in direct drive

(7) Reverse — Chart #73-26

(a) Front clutch and rear band are applied

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(b) Front clutch locks input to the rear sun gear

(c) Rear band holds rear planet carrier

(d) Front carrier idles in reverse

e. Removal and reinstallation

(1) Safety precautions

(a) Personal safety - remove rings, watches and any other jewelry ENFORCE!!!

(b) Disconnect battery ground cable

(c) Properly jack and support the vehicle

(d) Use transmission jack

(e) Wipe up spilled fluid

(2) Removal Procedures

(a) Remove flywheel inspection cover and flywheel and converter for balance

(b) Drain converter using a six point socket on drain plugs

(c) Loosen oil pan or remove drain plug to drain transmission

(d) Follow manufacturer's manual for disconnect points NOTE: converter and transmission must be removed and replaced as an assembly

(3) Installation Procedures

(a) Basically reversal of removal procedures

(b) Follow applicable manual

APPLICATION:

1. Ref: Para B, part 1.

Use TO 36A2-5-14-2 and following tech data, using special and hand tools disassemble transmissions (Torqueflite)

CONCLUSION 15 Min

SUMMARY AND REMOTIVATION

1. The main purpose of the torque converter is to multiply torque and act as a clutch. The impeller (drive member) is driven by the engine and transmits the torque to the turbine (driven member) through fluid which turns the transmission input shaft. The stator redirects the oil flow to cause torque multiplication. In the torqueflite, we have two simple planetary gear sets with a sun gear common to each set. (Simpson Design). The Simpson planetary arrangement is controlled by two clutches, two bands, and an overrunning clutch (Sprag Unit). The rear clutch is applied in all forward speeds. In 1st speed (drive range) the overrunning clutch holds the rear planetary carrier which transmits power through both gear sets. In manual low the only difference is the rear band holds the rear planet carrier which allows for engine braking. In 2nd speed the front band is applied and holds the sun gear which transmits the torque through the front planetary gear set. In 3rd speed (direct drive) the front and rear clutches are applied and locks the front ring gear and sun gear to the input shaft. In reverse, the rear clutch and rear band are applied and torque is reversed in the rear planetary gear set. During removal of an automatic transmission, we must follow the applicable manual and all safety precautions.

(Conduct short question and answer period).

Conservation of Utilities and Resources

ASSIGNMENT AND CLOSURE C/T POI Para 7a

2 Hrs

Continue assigned areas of 3ABR47330-SG-506

LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE TWSTI /7 Feb 75/	INSTRUCTOR
COURSE NUMBER 3ABR4[redacted] 47232	COURSE TITLE General Purpose Vehicle R[redacted]n Mechanic, Part I
BLOCK NUMBER V	BLOCK TITLE Power Trains

LESSON TITLE
Hydraulic Operation and Repair of Subassemblies of the Torqueflite Transmission

LESSON DURATION

CLASSROOM/Laboratory	xxxxxxxxxx/Complementary	TOTAL
D&D 2 hrs/Perf 4 hrs	2 hrs	8 hrs

POI REFERENCE

PAGE NUMBER	PAGE DATE	PARAGRAPH
33	2 January 1975	7

STS/CTS REFERENCE

NUMBER	DATE
473X0	3 September 1974

SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
1. Torqueflite auto transmission 2. Mechanic's Common Hand tools 3. Special tools	None	None	1. 3ABR47330-SG-506 2. T036A2-5-14-2

CRITERION OBJECTIVES AND TEACHING STEPS

a. Without references, identify basic facts and terms relative to the hydraulic operation in the torqueflite transmission with 70% accuracy.

b. Supplied with bench items, tools, equipment, and technical publications, and using appropriate safety practices, disassemble, inspect, and reassemble subassemblies of the torque flite transmission IAW technical publications.

Teaching Steps are Listed in Part II.

☆ GPO: 1973 779-396/23

INTRODUCTION 15 Min

1. Attention and Motivation: Relate to students how knowledge of various components in the hydraulic system is necessary in order to ensure proper operation of the transmission when reassembled.

2. Review: Review the construction and mechanical operation of torqueflite and how this knowledge is helpful during revuilding procedures. Check progress on 3ABR47330-SG-506, correct any mistakes.

3. Overview: Briefly describe the necessity of various hydraulic components for proper transmission operation.

BODY 5 Hrs 30 Min

PRESENTATION

1. Ref: Para a & b, Part 1

Discussion & demonstration will be performed in lab area

  a. Front Pump
    (1) Rotors
      (a) provide sufficient volume to create pressure
      (b) inspected for scores, pitting, and clearance in pump body
    (2) Pump body and Reaction Shaft Support
      (a) provides support & fluid passages
      (b) inspect for nicks & burrs
      (c) inspect bushings, seals, & interlocking seal rings
  b. Front Clutch
    (1) Piston
      (a) converts hydraulic pressure to mechanical force
      (b) inspect piston bore, seals, seal grooves, & return springs
    (2) Dirve and Driven Discs

- (a) locks sun gears & shell to input
- (b) inspect drive disc friction facing & splines
- (c) inspect steel driven discs

(3) Housing

- (a) inspect disc grooves, front band contacting surface, & ball check
- (b) inspect seal surfaces, bushing, & clutch plate clearance upon reassembly

c. Rear Clutch

(1) Piston

(converts hydraulic pressure to mechanical force

- (b) inspect piston bore, seals, seal grooves, & ball check

(2) Drive and Driven Discs

- (a) lock front ring gear to input
- (b) inspect driven disc friction facing & front clutch hub splines
- (c) inspect steel drive discs

Use TO
36A2-5-14-2 Common Hand
and Special Tools to
remove inspect repair
torqueflite components

(3) Input Shaft and Housing

- (a) inspect interlocking seal rings, bushing & thrust washer on input shaft
- (b) inspect disc grooves, seal surfaces, & return spring
- (c) measure clutch plate clearance upon reassembly

d. Front Servo and Band

- (1) Servo
  - (a) converts hydraulic pressure to mechanical force
  - (b) inspect piston, seal rings, & bore in case
- (2) Band
  - (a) holds sun gear reactionary
  - (b) inspect band & friction lining

e. Rear Servo and Band

- (1) Servo
  - (a) converts hydraulic pressure to mechanical force
  - (b) inspect piston, seal, & bore in case
- (2) Band
  - (a) holds rear planetary carrier reactionary
  - (b) inspect band & friction lining

f. Governor and Support

- (1) Valve & weights
  - (a) meter pressure according to output shaft speed
  - (b) inspect valve, inner & outer weight, & spring
- (2) Governor Body and Support
  - (a) provides fluid passages & parking gear
  - (b) inspect bores, seal rings, & parking gear lugs

g. Accumulator Piston

- (1) cushions the application of front band

    - (2) inspect piston, seal rings, piston bore in case, & spring
- h. Valve Body Assembly
    - (1) flow control valves
        - (a) provide manual & automatic control of transmission
        - (b) inspect all valves & valve springs
    - (2) Housing, Transfer Plate, & Separator Plate
        - (a) houses valves & provides fluid passageways
        - (b) inspect all mating surfaces, valve bores, passageways, & metering holes
- i. Planetary Gear Train
    - (1) hydraulically controlled to provide gear reduction & direct drive
    - (2) inspect bearing surfaces, oil passages, & splines on output shaft
    - (3) inspect bushings & thrust washers
    - (4) inspect sun & ring gears, & planetary carriers & gears
- j. Overrunning Clutch
    - (1) inspect rollers, roller races, & roller springs
    - (2) inspect cam set screw

APPLICATION:

1. Interspersed throughout presentation.

EVALUATION:

1. Question students on pertinent information.

CONCLUSION 15 Min

SUMMARY AND REMOTIVATION:

1. Today's lesson has shown & explained the function, construction, & inspections of nearly all components in the Torqueflite. In order for any transmission to function as designed, the components must be in the proper condition.

ASSIGNMENT AND CLOSURE: CTT POI Para 8a 3ABR47330-SG-506 2 hrs

1. Review the material covered today & tomorrow we will reassemble the transmission & discuss troubleshooting.

LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE TWSTI /7 Feb 75/	INSTRUCTOR
COURSE NUMBER 3ABR[redacted] 47232	COURSE TITLE General Purpose Vehicle [redacted]n, Part I Mechanic
BLOCK NUMBER V	BLOCK TITLE Power Trains

LESSON TITLE
General Automatic Transmission Maintenance Procedures

LESSON DURATION

XXXXXXXX/Laboratory D&D Perf 4.5 hrs	XXXXXXXXXX/Complementary 0 hrs	TOTAL 4.5 hrs

POI REFERENCE

PAGE NUMBER 34	PAGE DATE 2 January 75	PARAGRAPH 9

STS/CTS REFERENCE

NUMBER 473X0	DATE 3 September 1974

SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
1. Torque flite Transmissions 2. Vacuum control units 3. Engine dynamometer w/automatic trans 4. Mechanic's common hand tools 5. Special tools	None	None	1. 3ABR47330-SG-506 2. T036A2-5-14-2 3. T036A2-3-20-2-1 4. T036A2-4-22-2

CRITERION OBJECTIVES AND TEACHING STEPS

a. Provided with tools, equipment, vehicles, engine trainers w/transmissions and observing appropriate safety practices, use visual and operational means to perform leak detection, band and linkage adjustments, vacuum control unit checks and, determine fluid change procedures on automatic transmissions IAW Technical Publications.

Teaching Steps are Listed in Part II.

INTRODUCTION 15 Min

1. Relate to students the importance of regular maintenance of transmissions to ensure proper operation, dependability, and good driveability. Also how preventative maintenance can prevent later malfunctions and labor.

2. Review construction and operation of automatic transmissions. Conduct oral appraisals on assignment. Test and grade outside assignment: Reteach as needed. Check on completion of assignment in 3ABR47330-SG-506.

3. Briefly describe the basic maintenance & adjustments common to automatics.

BODY 4 Hrs

PRESENTATION:

1. Ref: Para a, Part 1	
a. Maintenance	Use Torqueflite transmissions
(1) Preventative Maintenance	
(a) Fluid Level	
1 Engine & transmission normalized	HOT!!
2 Selector Lever must be moved through all ranges	To fill passages
3 Place transmission in neutral, check level on dipstick	DO NOT OVERFILL
(b) Fluid changes and filter replacement	
1 Follow manufacturer's manual	On some vehicles, it is not necessary
2 Usually done more often under severe operating conditions	Ford - Type F
(c) Visual Inspections	Show vacuum control units
1 Linkage	
2 External leakage	
3 Vacuum connection & hose on vacuum modulator	

b. Adjustments	
(1) Band adjustments	Demonstrate operation of the engine transmission dynamometer trainers
(a) Correct servo piston travel	
(b) Adjusted at specified intervals	
(c) Adjusted when needed	
(d) Adjusted according to mfg specs	
(2) Throttle Valve Adjustment	Use common and special tools as required to make adjustments
(a) Adjusted to obtain proper shift points	
(b) Adjusted to mfg specs	
(3) Manual Valve Linkage	
(a) Check trans. and engine mounts	Why?
(b) To obtain proper range of operation	
(c) According to mfg spec	
(4) Pointer Alignment	
(a) Adjusted after manual linkage	
(b) Usually on steering column	
(c) According to mfg specs	
(5) Safety Starter Neutral Switch	
(a) On transmission (torqueflites)	
(b) In linkage (C-4)	
(c) According to mfg specs	

APPLICATION: Interspersed throughout body.

1. Ref: Para a, Part 1.

TO 36A2-5-14-2
TO 36A2-3-20-2-1
TO 36A2-4-22-2
Band Adjusting Tools
Hand Tools
Bench Items

EVALUATION:

1. What would cause aeration of transmission fluid?
2. What preliminary checks are made before initiating troubleshooting procedures?
3. When performing band adjustment, what is actually being corrected?
4. What is the purpose of the safety starter neutral switch?
5. What is controlled by the throttle valve linkage adjustment?
6. What could cause an automatic transmission to overheat during operation?
7. When should bands be adjusted?

CONCLUSION 15 Min

SUMMARY AND REMOTIVATION:

1. Preventive maintenance is necessary to ensure the proper operation & long-life of an automatic transmission. Maintaining transmissions adjustments will extend the life of transmission components and improve vehicle performance.

ASSIGNMENT AND CLOSURE:

1. Review today's lesson and accomplish new day's assignment 3ABR47330-SG-701 in preparation for Block 7 - Conservation of utilities and resources -

STUDY GUIDE 3ABR47~~330~~232-SG-500

WORKSHEET 3ABR47330-WS-504

Technical Training

General Purpose Vehicle ~~Repairman~~ Mechanic

BLOCK V
POWER TRAINS AND DUMP TRUCK CONTROLS

13 April 1970

CHANUTE TECHNICAL TRAINING CENTER (ATC)

Designed For A[illegible] Course Use

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Training Publications are designed for ATC course use only. They are updated as necessary for training purposes, but are not to be used on the job as authoritative references in preference to Technical Orders or other official publications.

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August 1969

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Vehicle Maintenance Branch
Chanute AFB, Illinois

3ABR47330-SG-501

CLUTCHES, STANDARD TRANSMISSIONS, AND POWER TAKEOFF

OBJECTIVES

After completing this unit of instruction, you will understand the purpose, operating principles, and types of automotive clutches, standard transmissions and power takeoffs. You will also be able to disassemble, inspect, repair and reassemble these units.

INTRODUCTION

In previous lessons you learned of the power plant and its accessories. You are now ready to learn how the power developed by the vehicle engine reaches the vehicle wheels so that the wheels will rotate and cause the vehicle to move. This is done through a series of gears and shafts, commonly called the power train, which mechanically connect the engine shaft with the vehicle wheels. The purpose of the power train is to carry the power of the engine to the wheels and accessory equipment. In a simple situation, a set of gears or a chain could perform this task. However, automotive vehicles are not usually made for such simple operating conditions. They have great pulling power, move at high speeds, travel in reverse as well as forward and operate over rough ground as well as on smooth roads. To meet these varying demands, a number of units have been added. Included in these units are the clutch, transmission and power takeoff.

INFORMATION

Information relative to the purpose, operating principles, and instructions for the disassembly, inspection, repair and reassemble of automotive clutches, standard transmissions and power takeoffs is contained in Programmed Text 3ABR47330-PT-501. Read this information carefully and then answer the questions contained therein.

Vehicle Maintenance Branch
Chanute AFB, Illinois

3ABR47330-SG-502

CLUTCH AND TRANSMISSION REMOVAL AND REPLACEMENT

OBJECTIVES

Upon completion of this unit of instruction, you will be able to remove, inspect, install, and adjust clutch and transmission by using special tools and equipment and applying all safety precautions.

INTRODUCTION

Because of the variations in construction of transmissions on different type vehicles, different procedures must be followed when removing and installing the transmission. Basically the procedures are similiar. By using the proper equipment it can be lowered to the floor or raised through the body, as specified. As with transmissions, the clutch, due to the differences in construction and design, make it necessary to use somewhat different procedures and tools when removing it from the vehicle. The first step in clutch removal is to remove the transmission.

INFORMATION

As previously stated, the removal and installation procedures for clutches and transmissions may vary on certain vehicles. It would be impossible to give a step-by-step procedure for these jobs at this time. Prior to performing these tasks you will participate in a discussion relative to the procedures for removing the clutch and transmission. You will perform these jobs by using applicable vehicle publications and following a task list and procedures as outlined by the instructor. Special emphasis will be stressed on all safety precautions pertaining to these projects.

Vehicle Maintenance Branch
Chanute AFB, Illinois

3ABR47330-SG-503

TRANSFER CASE, SPRAG UNITS, PROPELLER SHAFTS, CENTER BEARING, UNIVERSAL JOINTS, AND WINCH

OBJECTIVES

After completing this unit of instruction, you will understand the purpose, constructional features, and operating principles of the transfer case, sprag unit, propeller shafts, center bearing, universal joints and winch. You will also be able to disassemble, inspect, repair and reassemble these units.

INTRODUCTION

As stated in a previous lesson, the purpose of the power train is to carry the power of the engine to the wheels and accessory equipment (such as winches) of the vehicle. This is accomplished by a number of units. These include transmissions, clutches, auxiliary transmissions, transfer cases, universal joints, slip joints, differentials, and final drives. It is the responsibility of the general purpose vehicle repairman to maintain and keep these units in a fully operational condition at all times. To accomplish this, the mechanic must be able to perform any needed operational testing, service and repair of these units.

INFORMATION

Programmed Text 3ABR47330-PT-503, contains information on the construction, operating principles, servicing and repair of these units. Also included is procedures for the removal and installation of power train units. Read this information carefully and answer the questions contained therein.

CONVENTIONAL AND ANTI-SPIN DIFFERENTIAL AND FRONT DRIVING AXLE

OBJECTIVES

After completing this unit of instruction, you will understand the purpose, construction, and operating principles of differentials and front-driving axles. You will also learn the procedures for removing, disassembling, inspecting and repairing these units.

INTRODUCTION

Some heavy-duty vehicles have driving axles in the front as well as the rear. The primary differences between front and rear driving axles is that front driving axles must have a means of steering. All driving axles contain a differential. The purpose of the differential is to provide for differences in speed of rotation of wheels as a vehicle rounds a corner or travels over uneven ground. Basically there are two types of differentials, conventional and non-slip.

INFORMATION

To learn the purpose, construction, and operating principles of the drive axles and their components carefully read the information contained in Programmed Text 3ABR47330-PT-504, and study its illustrations. You will learn the procedures for servicing, repairing, and troubleshooting these units by completing the tasks as outlined in Worksheet 3ABR47330-WS-504, and as directed by your instructor.

Vehicle Maintenance Branch
Chanute AFB, Illinois

3ABR47330-WS-504

CONVENTIONAL AND ANTI-SPIN DIFFERENTIAL AND FRONT-DRIVING AXLE

OBJECTIVES

When you have completed this Worksheet you will be able to:

Disassemble and reassemble the drive axle.

Inspect the axle and its components.

Repair and adjust the axle and components.

EQUIPMENT

Driving Axle
Axle Stand
Mechanics Tool Set

PROCEDURE

Exercise 1

Using the worksheet as a guide for step-by-step procedures and important information, perform each task as outlined and as directed by the instructor.

PROCEDURE	IMPORTANT INFORMATION
1. Practice all safety precautions applying to the project.	1. Think Safety-Practice Safety-Act Safely.
2. Obtain applicable publications from the file.	2. Publications title or technical order No.
3. Prepare to disassemble and reassemble a front driving axle.	3. Check for special tools, parts containers, drain pans, rags, etc.
4. Drain lubricant from the front axle housing.	4. Inspect drained lubricant for broken parts or metal chips.
5. Place front axle in a safe position.	5. Be sure front axle will not fall from work bench or stand.
6. Make preinspection of front axle.	6. Inspect front axle for cracks, leaks, gaskets, seals or other damage.

7.	Remove differential cover, and inspect drive gears for damage and adjustments.	7.	Check the pinion and drive gear adjustment for looseness, tightness, end play, side play, heel wear, toe wear, drive pinion too far ahead or back, rough or worn gear teeth.
8.	Inspect differential gears (pinions) for free turning.	8.	Inspect the differential by turning one hub or wheel, holding the other one still. The differential pinions should rotate inside the differential case between the axle shaft side gears.
9.	Remove the wheel hubs.	9.	Place parts in a parts pan containing cleaning solvent. Parts must be cleaned before they can be used again.
10.	Remove steering knuckle (spindle arm) including seals and retainers.	10.	The retainers and seals must be removed first, the bearing caps and shims next, then the steering knuckle (spindle arm) can be removed.
11.	Remove axle shaft and universal joint.	11.	The axle shaft and U-joint can be pulled out by hand.
12.	Remove differential bearing caps, and differential case with gears.	12.	It may be necessary to use a special tool for spreading the housing, if the differential case is tight in the housing.
13.	Remove drive pinion and bearings.	13.	A special tool, or a soft mallet can be used to remove this pinion and bearings.
14.	Clean and inspect the axle housing including the steering knuckles.	14.	Clean the axle housing and steering knuckles. Inspect for grindings or chips.
15.	Clean and inspect all bearings used in the driving axle.	15.	All bearings must be washed clean inspected for rough spots on the rollers or races.
16.	Clean and inspect all gears, replace worn gears.	16.	Wash all gears in cleaning solvent, inspect for worn or rough spots, replace all gears if they are worn or rough.

17. Clean and inspect axle shafts, splines, and universal joints.	17. Clean axle shafts, universal joints and splines on the axle shafts. Inspect for wear. Be sure to inspect the splines on end of the axle shafts, if worn the axle shaft must be replaced.
18. Check and order the oil seals and gaskets needed.	18. Oil seals and gaskets are usually replaced after removal.
19. Check and prepare all parts and equipment for reassembly.	19. Are you prepared to assemble the driving axle? Have you the proper parts, tools, gaskets, seals, gages, oil and greases?
20. Replace the drive pinion in the axle housing.	20. Be sure good bearing are used, lubricated and adjusted. Special gages are used for making adjustments. Ask your instructor about adjustments or refer to the proper publication.
21. Replace the drive gear and differential in axle housing.	21. Replace differential gears in differential case with drive gear, and place the assembly in the axle housing.
22. Adjust drive gear and pinion backlash (free play).	22. This backlash adjustment is the amount of free play (movement) you can turn the drive gear without turning the drive pinion. It can be measured with a dial gage.
23. Replace axle shafts and universal joints.	23. Push and turn on the axle shaft until the splines slide into the differential side gear.
24. Place knuckle oil seals over axle housing ends.	24. New oil seals should be used to keep grease in and dirt out.
25. Replace steering knuckles (spindle arms) and adjust bearings.	25. These bearings should be adjusted with a preload. Refer to the applicable publication for specifications.

26. Bolt oil seals in place on the steering knuckles (spindle arm).	26. After the oil seals have been bolted in place, the turning (preload) load will increase but this does not count with the specifications.
27. Replace wheel hubs, and brake carrier plates.	27. Wheel hubs use ball or roller bearings. These bearings must be well packed with wheel bearing grease, and proper adjustments made. Refer to the proper publication for wheel bearing adjustment.
28. Replace differential cover.	28. When replacing the differential cover a new gasket must be used. Be sure it does not leak grease.
29. Make final check for missing parts, loose bolts, nuts, washers, seals, gaskets, keys, locks or plugs.	29. "Think." If you were going to place this axle under a vehicle, would you be willing to ride down the highway in it at 60 miles per hour?
30. Lubricate.	30. Ask your instructor if you should fill this axle housing to proper level with lubricant. If so refer to the applicable publication for proper lubrication and level.
31. Participate in a critique of the completed project (job).	31. Your instructor will conduct the critique. Be prepared to ask and answer questions.

Exercise 2

PROCEDURE

Referring to items 1 through 8, complete the statements by listing the applicable units and components in spaces provided.

Referring to figures 1 through 4, list the units and components as shown in the spaces provided.

1. Power from the propeller shaft is changed 90 degrees and transmitted to the driving axle by the ______________ ______________.

2. A flexible connection is provided in the front driving axle housing by the ______________ ______________ ______________ and ______________ ______________.

3. A flexible connection is provided between the inner and outer axle shafts of a front driving axle by the ____________ ____________.

4. Differences in speed of rotation of wheels in turns is provided by the________________ __________________.

5. Torque is transmitted from the differential gear to the wheels by the_______________ __________________.

6. Gear reduction takes place in a single reduction axle between the _______________ gear and the _______________ gear.

7. To obtain a larger gear reduction and keep the ring gear and its housing relatively small, a ______________ _________________ driving axle is used.

8. Types of axles:

a. ____

b. ____

CONSTANT VELOCITY U-JOINTS

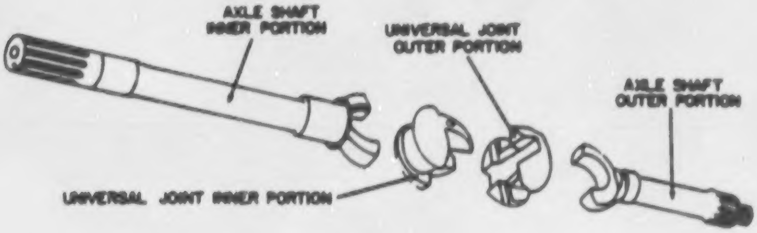
AXLE SHAFT INNER PORTION
UNIVERSAL JOINT OUTER PORTION
AXLE SHAFT OUTER PORTION
UNIVERSAL JOINT INNER PORTION

Figure 1: ____________________________

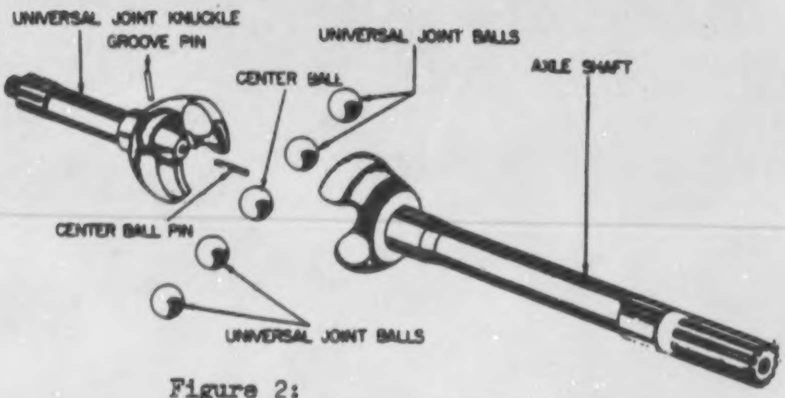
UNIVERSAL JOINT KNUCKLE
GROOVE PIN
CENTER BALL
UNIVERSAL JOINT BALLS
AXLE SHAFT
CENTER BALL PIN
UNIVERSAL JOINT BALLS

Figure 2: ______________________________

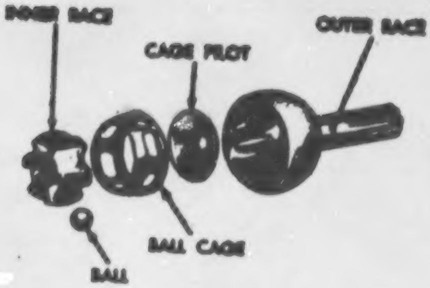
INNER RACE
CAGE PILOT
OUTER RACE
BALL CAGE
BALL

Figure 3: ______________________________

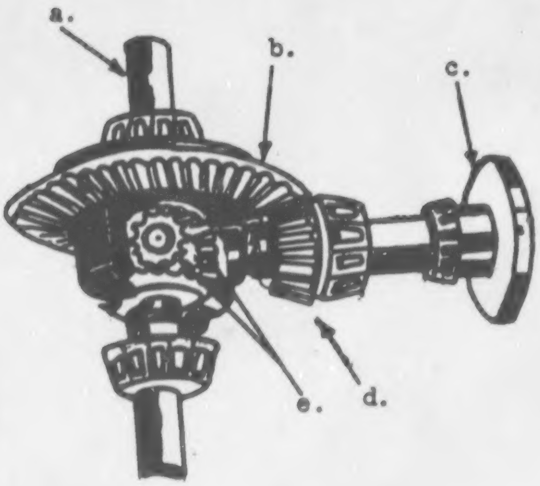

Figure 4

Components (Figure 4):

a. __________ __________ __________
b. __________ __________
c. __________ __________
d. __________ __________
e. __________ __________

Vehicle Maintenance Branch
Chanute AFB, Illinois

3ABR47330-SG-505

AUTOMATIC TRANSMISSIONS

OBJECTIVES

After completing this unit of instruction, you will understand the constructional features, operating principles, and troubleshooting procedures of fluid couplers, torque converters and automatic transmissions. You will also gain a general knowledge of adjustments required on automatic transmissions.

INTRODUCTION

A transmission is a variable fulcrum that gives the internal combustion engine greater flexibility of performance and application. The transmission can multiply the engine output torque many times. Without a transmission the internal combustion engine would stall out unless, of course, the engine size is out of proportion to the work it is doing. From a previous lesson you learned that the purpose of any transmission was to provide different gear ratios and a reversing capability through the use of different gear arrangements. As you know, a standard transmission requires manual shifting of the gears to provide the different forward speeds and reverse capability. In the automatic transmission, the gears are never shifted, and yet the automatic transmission will provide these same things.

INFORMATION

For more information of automatic transmissions, carefully read the information in Programmed Text 3ABR47330-PT-505, and study its diagrams and illustrations. This instructional material is relevant to the construction, operating principles, service, maintenance, adjustment, and troubleshooting of automatic transmissions, torque convertors and fluid couplings.

Vehicle Maintenance Branch
Chanute AFB, Illinois

3ABR47330-SG-506

HYDRAULIC HOISTS AND CONTROLS OF DUMP TRUCKS

OBJECTIVE

After completing this unit of instruction you will understand the purpose, construction, and operating principles of hydraulic hoisting mechanisms, mechanical control systems and be able to remove, inspect, repair or replace, and adjust components of a dump truck.

INTRODUCTION

The dump truck, as shown in figure 1, is used to transport and dump materials such as: stone, sand, gravel, and dirt. It may also be used to transport general cargo.

Figure 1. Typical Commercial Design Dump Truck.

INFORMATION

DUMP TRUCK CONSTRUCTION AND OPERATION

There are several sizes and makes of dump trucks, however, the construction and operation is basically the same. The body is made of steel and is raised by a hydraulic system. This system is controlled by the driver of the vehicle through rods and levers. The dump body is hinged

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at the rear and is equipped with a hinged tailgate. The tailgate may be opened from either the top or bottom, as shown in figures 2, and 3, allowing it to be utilized either as a cargo or dump truck.

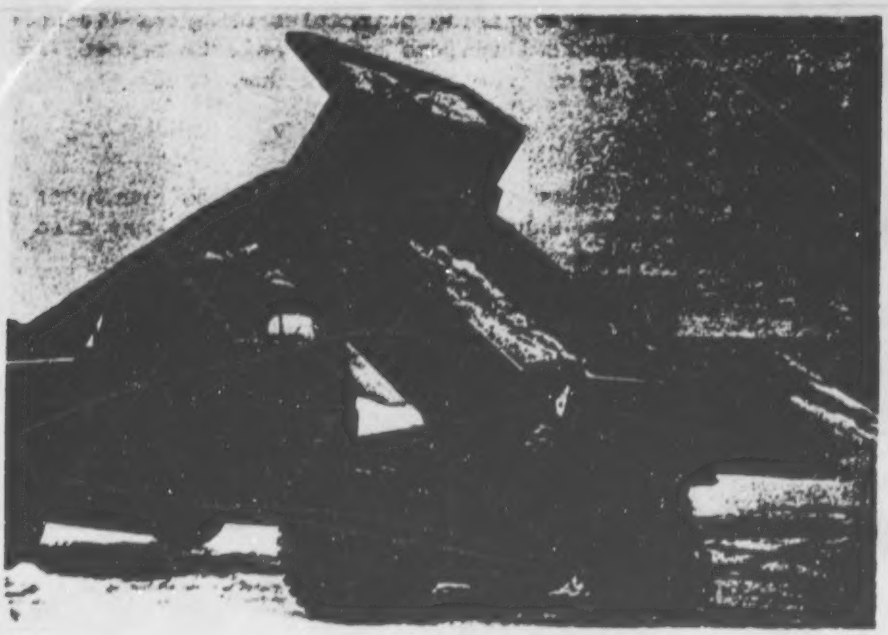

Figure 2. Dump Truck in Dump Position.

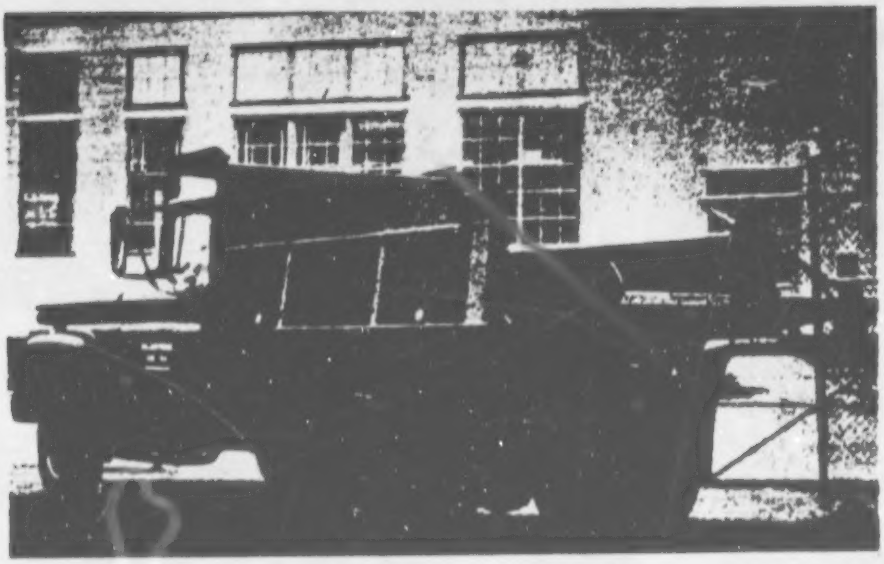

Figure 3. Dump Truck - End Gate Down.

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Dump Body Operation

The dump body is usually controlled by a lever, or levers, in the operator's cab. The first step is to power the hydraulic pump. The pump receives its power from the power takeoff. Once the PTO is engaged the dump body may be raised by putting the lever in the "UP" position. At any point when it is determined that the body is raised high enough the lever can be placed in the "HOLD" position. This will hold the dump body at that position until the lever is again moved. To lower the bed the lever is placed in the "DOWN" position. The speed in which the bed is raised or lowered is determined by how far the lever is placed in the "UP" or "DOWN" position. The tailgate is opened at the bottom by a lever located on the front of the dump body as shown in figure 4. The amount it is allowed to open is controlled by an adjustable chain on the tailgate. The top may be opened by removing the pivot pins from the top of the tailgate.

Figure 4. End Gate Latch Being Released.

Hydraulic Hoistings System Components

On all hydraulic systems certain components are necessary. These components may vary on different systems as to their amount, size, design, etc. In other words, the method of transforming power into fluid pressure over certain distance may vary on different hydraulic systems. Where one system may depend on an ordinary hand pump to accomplish this, another may use the hydraulic pump driven from an external source, such as used on the dump truck. Another variation of the systems may be the amount of units that the hydraulic system is required to operate. The major components of the hydraulic system of the dump truck consist of the pump, pressure relief valve, control valve, hoist cylinder, reservoir, and hydraulic lines and fittings.

Pump

The hydraulic pump, shown in figure 5, is of the positive-displacement gear type. The pump is bolted to the truck frame and is driven by the PTO through a shaft shown at the lower right of the figure.

Pressure Relief Valve

The purpose of the pressure relief valve is to relieve the pump of excessive hydraulic pressures which could result in blown seals or ruptured hoses. You will find in most cases that this valve is of the spring-loaded spool type. This valve may be adjusted by increasing or decreasing the spring tension. The valve is located within the pump body.

Control Valve

Movement of the control valve determines the raising, lowering, or holding position of the dump body. This valve is either of the spool or spool type and is actuated through linkage by the vehicle operator from within the cab. Depending on the valve's position it will either route the fluid to the elevating side of the cylinder to raise the body, or it will allow the fluid to drain or return from the cylinder to lower the body. Also, the valve may be positioned so that the dump body can be held in any desired position. The valve is an integral part of the pump. (Figures 7, 8, and 9, which appear at the end of this study guide, illustrate the various valve positions.)

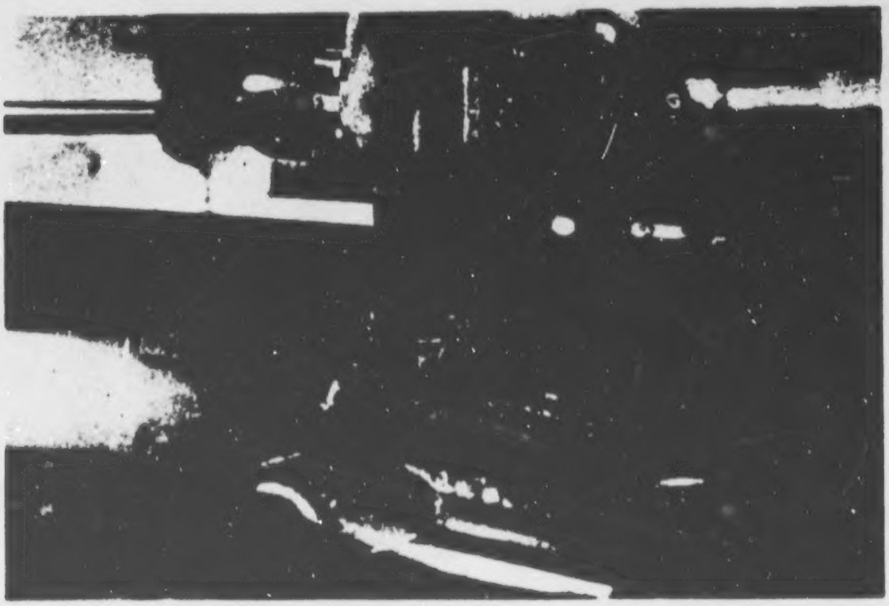


Figure 5. Typical Dump Truck Hydraulic Pump.

Hoist Cylinder

The hoist cylinder is used to raise and lower the dump body efficiently and smoothly.

SINGLE-ACTION CYLINDERS. Fluid under pressure enters the cylinder and forces the push rod up. The push rod is lowered by gravity and the fluid is bled off back into the reservoir.

DOUBLE-ACTION. Fluid under pressure forces the push rod up and down. This type cylinder allows the dump body to reach a near vertical position. In this case pressure may be required to start the dump body down, however, gravity should be allowed to finish the lowering of the dump body.

TELESCOPIC CYLINDER. This cylinder is used to extend the push rod more than twice the length of the cylinder. It works on the principle of a telescope. This type has a push rod within a push rod and will raise nearly three times the length of the cylinder.

Hydraulic Lines and Fittings

These lines (hoses), shown in figure 5, are used to deliver fluid from the control valve to the cylinder and back again. They may both be high pressure lines or one may be a low pressure line. If both are used they can be identified by a difference in diameter. The high pressure is normally smaller than the low pressure.

Reservoir

The reservoir is normally located inside the cylinder. The fluid is pumped from the top of the cylinder, and delivered under pressure to the bottom of the cylinder. In some applications the reservoir may be a separate tank.

Inspection and Repair of Dump Truck Units

One of the most common failures of the hydraulic system used on the dump truck is the complete loss of pressure or low pressure. Any signs of leakage should be corrected immediately. This includes the installation of new gaskets, adjusting packing, or tightening of nuts and bolts. All linkage should be inpected for tightness and any points of wear, such as clevises and pins should be replaced. The control valve should be checked for operation. It should work freely in all positions. The valve (provided it is the spring-loaded type) should snap back to neutral as it is released. The hoist cylinder ram should be smooth and free from rust. A fine film of hydraulic fluid on the ram indicates a properly adjusted packing gland.

Removal of Units From Dump Truck

When it is necessary to remove components of the hydraulic system of the dump truck, the dump body should be raised and properly blocked to prevent it from falling and injuring personnel working on the vehicle.

DISCONNECTING LINES. Keep suitable containers handy to catch the hydraulic fluid when lines are disconnected. Use the proper tools for disconnecting lines so that fittings will not be damaged.

> Note; The fittings and end of lines should be taped to protect fittings and prevent dirt from entering lines. Any dirt or foreign material may be very damaging to any hydraulic system.

REMOVING THE LIFT CYLINDER. Whenever it is necessary to remove the lift cylinder, an overhead crane or other suitable lifting device must be used to ease the task of handling the cylinder.

REMOVING THE HYDRAULIC PUMP. The pump is generally bolted to the frame. Mounting bolts, propeller shaft, linkage and lines must be removed in order to remove the pump from the truck.

REMOVAL OF THE CONTROL VALVE. This requires only the removal of linkage, lines, and mounting bolts to remove it from the vehicle.

Replacement of Units

Replacing the units of the hydraulic system is simply a reversal of procedures used when removing them.

Tests of Units

When units have been replaced it will be necessary to refill the reservoir or cylinder with the specified type of fluid. Make sure that no lines are left loose that will develop leaks under pressure. When units have been replaced and all necessary items checked, start the vehicle and check the operation. Adjust the linkage on the power takeoff and the control valve.

Servicing Hydraulic System Components

The hydraulic system of the dump truck is subject to leaking after an extended period of use. It is necessary that all lines, fittings, and gaskets be kept tightened or replaced (they cannot be repaired). Also, other servicing is required from time to time to keep the system in top operating condition.

LIFT CYLINDER. The lift cylinder is equipped with an adjustable packing gland that may require tightening. A properly tightened packing gland will not leak but does leave a film of fluid on the piston rod. Periodically, an inspection should be made to determine the specified fluid level of the reservoir or cylinder. It is necessary to add clean hydraulic fluid as required. The type of hydraulic fluid to be used is listed in the publication applicable to equipment in use.

> Caution: Overtightening of the packing will score the rod and leave it dry and subject to rusting.

LINKAGE. The mechanical control linkage may require servicing or adjusting after an extended period of use. The adjustment may be required to compensate for wear and possible bending of linkage. The adjustment is made by "trial and error." This means that the linkage is changed and checked repeatedly until the desired action is achieved in all positions of the control lever.

END GATE CONTROL. The end gate (tailgate) of the dump truck is held closed at the top by pins, and by latches at the bottom figure 6. The latches are controlled by a mechanical lever, figure 4, located at the front of the dump body. The lever connects the latches through mechanical linkage. The linkage may require periodic servicing and adjustment as the need arises.

Note: For additional information concerning the servicing of this type of Air Force equipment, it is suggested that reference be made to the applicable publications.

Figure 6. Typical End Gate in the Latched Position.

Safety Precatuions.

It is recommended that maintenance personnel observe all applicable safety precautions very closely when working on this type of equipment. The few additional minutes used to make sure that heavy parts will not slip or fall when parts are removed may keep personnel from serious injury and prevent costly damage to equipment. A few safety precautions that should always be observed when working on this type of equipment are as follows:

Maintenance personnel should always make sure that the dump body of the dump truck is carefully blocked after it has been raised for the purpose of making repairs to any unit attached on the underside of the vehicle. NEVER WORK UNDER A RAISED DUMP BED UNLESS IT IS PROPERLY BLOCKED.

Care should be exercised not to get hydraulic fluid or oil in the eyes.

Always wipe up any spilled hydraulic fluid from the floor or vehicle to prevent slipping and falling. This should be done immediately after it has been spilled.

It is often necessary to use a hoist or other suitable lifitng device when removing or handling heavy components on this type of equipment. The components should be carefully supported before being disconnected.

Exercise care when working with another mechanic. Always check to see what vehicle units have been loosened by other maintenance personnel before any attempt is made to remove such units as mounting bolts, etc.

Note: Remember! No attempt should be made to get under any unit that is ready for removal.

QUESTIONS

1. Where is the hydraulic fluid stored?

2. What indicates a properly adjusted packing gland?

3. How does the control valve regulate the motion of the dump bed?

4. Why does the end gate of a dump truck open at the bottom as well as the top?

5. How is the hydraulic pump on the dump truck driven?

6. How would hydraulic pressure be increased if more pressure were needed?

7. What could happen if the packing gland was adjusted too tightly?

8. How can the speed at which the cylinder operates be regulated?

9. What determines how wide the tailgate opens?

10. What type of cylinders are used on dump trucks?

Note: If you have difficulty answering these questions then by all means go back and review the material that you are weak on.

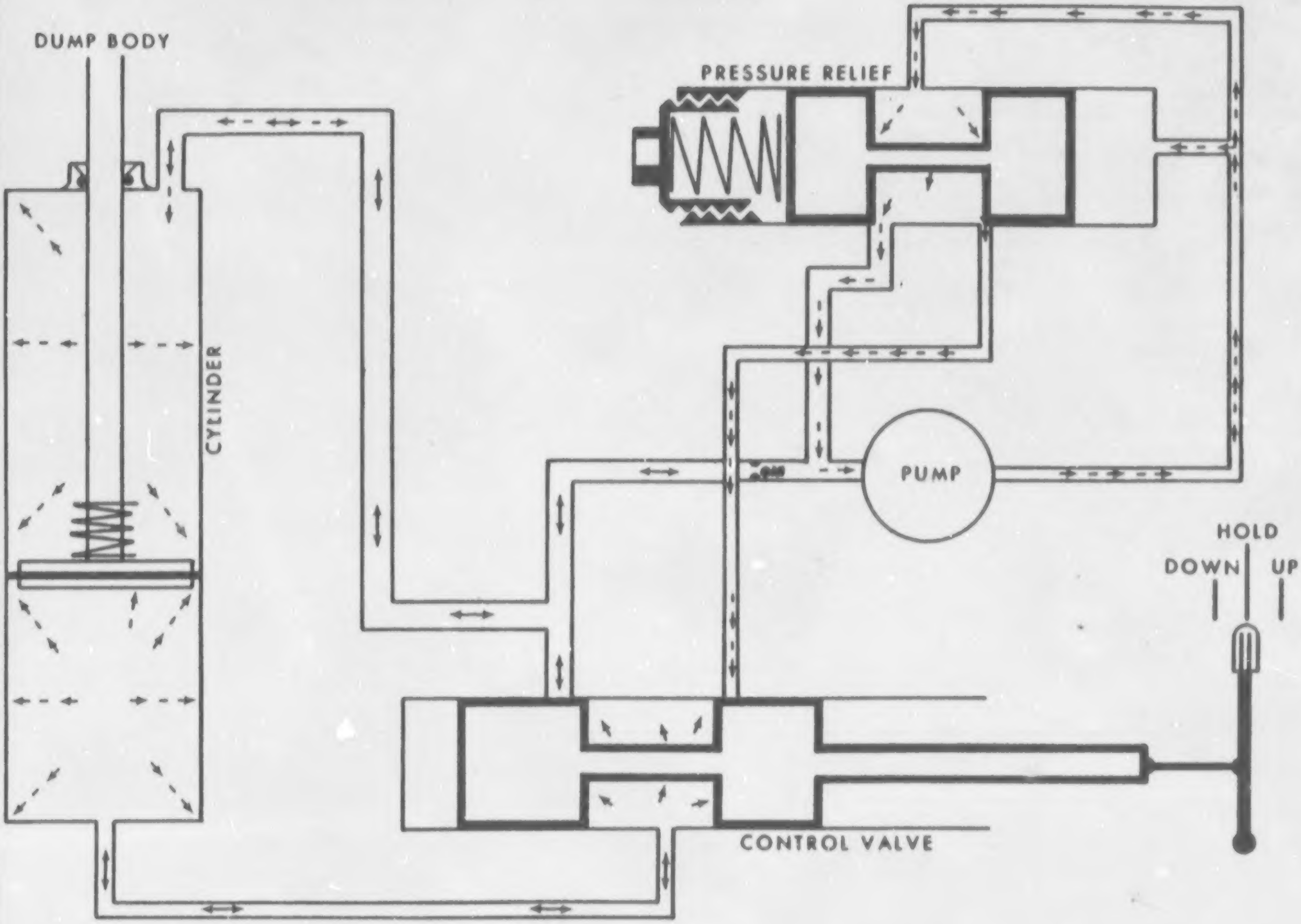

DUMP BODY
PRESSURE RELIEF
CYLINDER
PUMP
HOLD
DOWN
UP
CONTROL VALVE

Figure 8. Typical Dump Truck Hydraulic Control System in the "HOLD" Position.

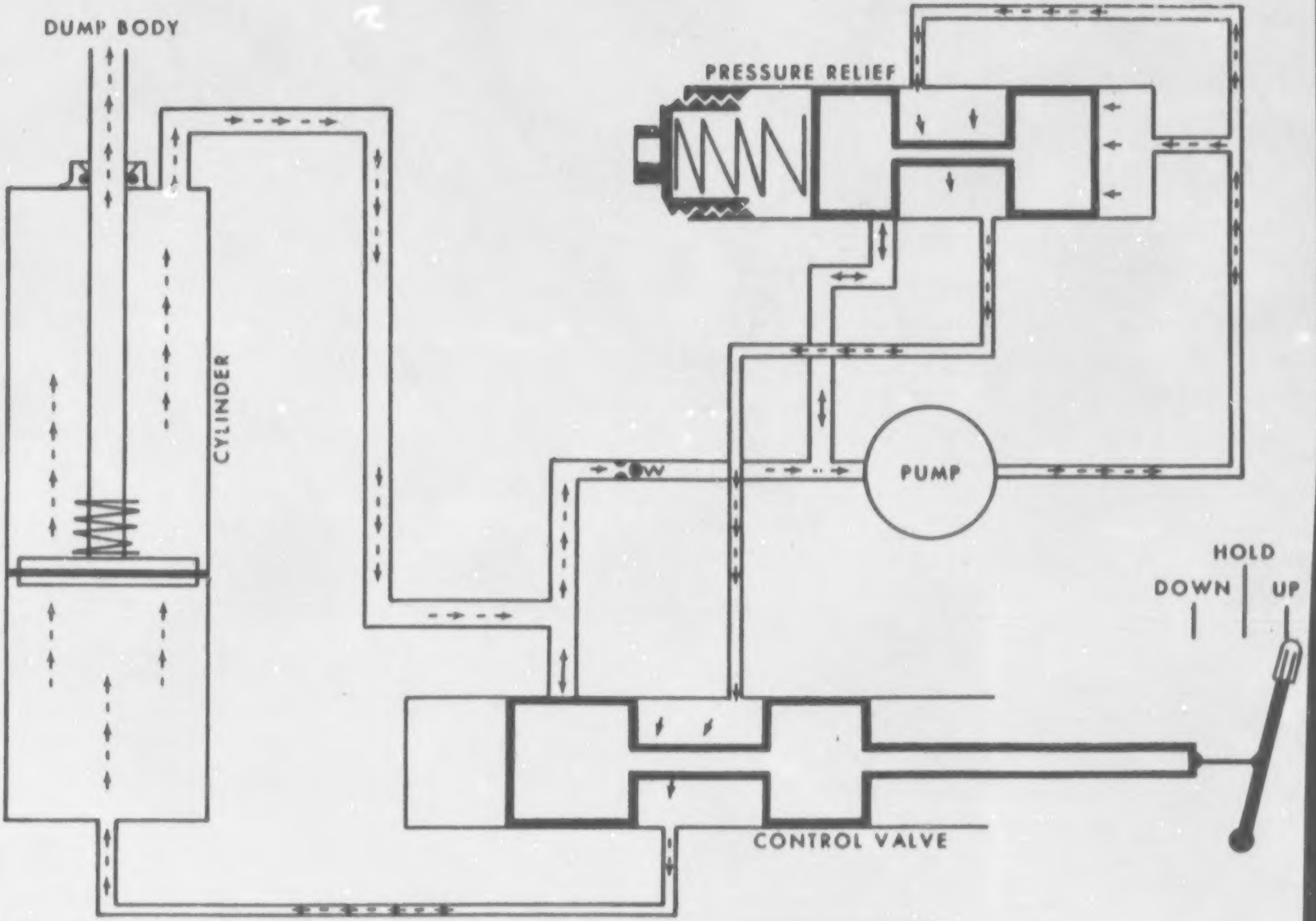

DUMP BODY
PRESSURE RELIEF
CYLINDER
PUMP
HOLD
DOWN
UP
CONTROL VALVE

Figure 7. Typical Dump Truck Hydraulic Control System in the "UP" Position.

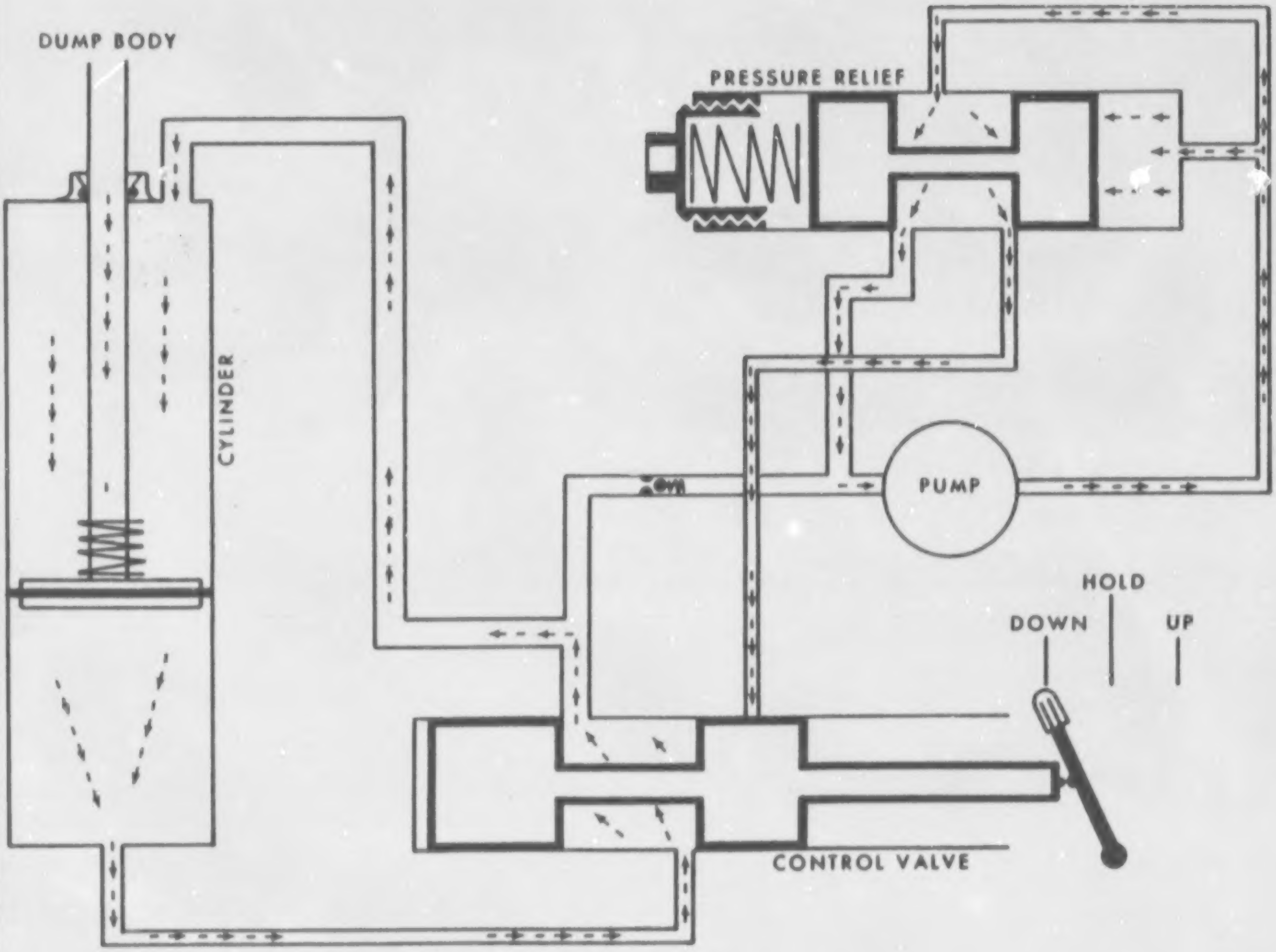

DUMP BODY
PRESSURE RELIEF
CYLINDER
PUMP
HOLD
DOWN
UP
CONTROL VALVE

Figure 9. Typical Dump Truck Hydraulic Control System in the "DOWN" Position.

PROGRAMMED TEXT 3ABR47~~330~~232-PT-501A

Technical Training

8-11

General Purpose Vehicle ~~Repairman~~ Mechanic

STANDARD TRANSMISSION

4 March 1970

CHANUTE TECHNICAL TRAINING CENTER (ATC)

This supersedes PT 3ABR47131-501B-II, 15 February 1968.

Designed For ATC Course Use

OBJECTIVES

After completing this programmed text you will be able to accomplish the following objectives with 80% accuracy.

1. Given a list of statements concerning a standard transmission, select those that best describe:

   a. The purpose of the standard transmission.

   b. The operating principles of the standard transmission.

2. Given a list of transmission units and a list of their purposes, match the unit to its purpose.

VALIDATION

This programmed text was validated on 30 students enrolled in the 3ABR47330 Course at Chanute AFB and has been in continuous use since that time.

INSTRUCTIONS

This program presents information in small steps. Each page or "frame" contains an information panel that is identified by a book symbol. In addition, each page generally contains a question or two pertaining to information contained in the last informational panel. Read the information presented within the solid-line box. Read the questioning statement. Select the correct statement in response to the question asked in the question-mark outlined box and make your response after the appropriate question number on the answer sheet provided. Make no marks in this program. The small step size of the information panels makes selection of the correct response an easy matter, and in most cases you won't have to be told the correct answer. However, if you don't know what the correct answer is, it (the answer) will be found in the box at the top of the next page. We hope that you see the light and answer correctly before referring to the answer box. That is why the sun-burst system (seeing the light) is used to identify answer panels in this program.

INTRODUCTION

A vehicle is required to operate under many different types of road conditions, such as rough hilly ground, sand, or smooth surfaces. It will require more power to go up a hill than to run on a level road. Therefore, a transmission is used to vary the amount of power delivered at different times.

An increase of torque may be necessary for a vehicle to pull up a hill. It may be that when the transmission is in LOW gear there is a gear reduction of 12:1 from the engine to the propeller shaft. This means that the crankshaft of the engine must turn over 12 times to turn the propeller shaft once. If the same vehicle was on a smooth road, the gear reduction is not needed and the transmission may be in direct drive with a 1:1 gear ratio. This means that the crankshaft of the engine must turn over only one time in order to turn the propeller shaft once. The transmission also provides a means for backing the vehicle. There is a need for many gear ratios in a vehicle and the transmission is the unit that provides the operator with a selection of gear ratios and reverse direction between the engine and the rear wheels.

QUESTION 1.

? ?

? What is the purpose of the standard transmission? ?

? a. To engage and disengage the engine from the rear wheels. ?

? b. To permit the engine to develop full torque. ?

? c. To provide the operator with a selection of gear ratios. ?

? d. To provide equal torque distribution to both driving wheels. ?

? ?

Frame 2.

The right answer to Question 1 was "c."

The standard transmission operates on the principle of gear ratio, which is usually defined as the relative speed of rotation between two meshing gears. The ratio is determined by the number of teeth on the gears. For example, two meshing gears having the same number of teeth will both turn at the same speed. The transmission provides a means of changing the gear ratio.

QUESTIONS 2 and 3.

? ?

2. What is the operating principle of a standard transmission?
   - a. Friction.
   - b. Gear ratio.
   - c. Transfer of motion by liquids.
   - d. Centrifugal force.
3. What unit on the vehicle provides the operator with a selection of gear ratios and reverse direction between the engine and the rear wheels?
   - a. Propeller shaft.
   - b. Engine.
   - c. Rear axle.
   - d. Transmission.

? ?

Answers to previous questions: 2. "b", 3. "d".

Most standard transmissions have an engine-to-drive shaft ratio of about 3 to 1 in FIRST gear. That is to say, the engine crankshaft will turn three times while the drive shaft turns only once. This engine-to-drive shaft ratio will produce high engine torque and low vehicle speed.

Shifting the transmission into SECOND gear generally results in a 2 to 1 engine-to-drive shaft ratio. A smaller gear is used to increase the speed of the drive shaft but this also decreases the torque delivered.

THIRD gear is essentially a 1 to 1 engine-to-drive shaft gear ratio. That is to say that for each engine revolution the drive shaft will also turn one revolution.

In each of the changes in gear ratio, speed is increased as the drive shaft revolutions approached that of the engine crankshaft. These changes in gear ratio are desirable once the vehicle is in motion. The ability of the engine to produce the necessary torque to move a vehicle from rest is decreased as the engine-to-drive shaft ratio is decreased.

Torque is a twisting effort or "that force which produces or tends to produce rotation." If gears are arranged to increase torque, speed is decreased but if they are arranged to increase speed, torque is decreased.

QUESTION 4.

? ?

What is the result in a transmission when a small gear on the input shaft drives a large gear on the output shaft?

a. Speed is increased and torque is decreased.
b. Speed is decreased and torque is increased.
c. Speed and torque are decreased.
d. Speed and torque are increased.

? ?

1

Frame 4.

"b" was the correct answer to the previous question

The transmission provides a means of varying gear ratios through the use of gears mounted on shafts. The gears and shafts are housed in the transmission case. An input shaft or clutch shaft is used to transmit torque from the engine into the transmission, while an output or mainshaft is used to transmit the torque from the transmission to the propeller shaft.

QUESTIONS 5 through 7

? ?

5. What is the purpose of the transmission case?
   - a. Provide the selection of different gear ratios.
   - b. Provide support between the engine and the transmission.
   - c. House the differential gears.
   - d. House the transmission gears and shafts.

6. What unit is used to transmit torque from the engine to the transmission?
   - a. Input shaft.
   - b. Output shaft.
   - c. Intermediate propeller shaft.
   - d. P.T.O. drive shaft.

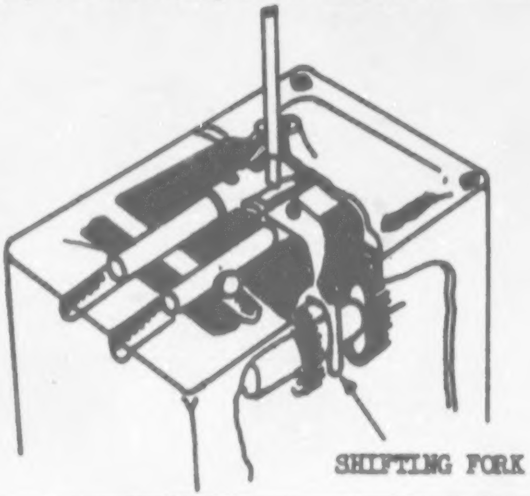
7. What unit is used to transmit torque from the transmission to the propeller shaft?
   - a. Input shaft.
   - b. Output shaft.
   - c. Intermediate propeller shaft.
   - d. P.T.O. drive shaft.

? ?

Frame 5.

Answers to previous questions: 5. d, 6. a, 7. b.

A shifting mechanism provides a means of changing the gear ratios in the standard transmission. If the shift control is mounted on the floor, it is normally connected, as shown in the figure below. When the lever is moved, the shifting forks are moved. This, in turn, moves the gears.



QUESTION 8.

? ?

? What is the purpose of the shifter mechanism? ?

? a. Transmits power from the shift lever to the main shaft. ?

b. Allows for different gear ratios.

? c. Automatically shifts power from the input shaft to the main shaft in the transmission. ?

? d. Provides a means of changing gear ratios. ?

? ?

Frame 6.

Answer to previous question: 8. d.

QUESTIONS 9 through 12.

? ?

Match the units on the left with their purposes as given on the right.

9. Transmission Case.

10. Input Shaft.

11. Output Shaft.

12. Shifter Mechanism.

a. Transmit power from the engine to the transmission.

b. House the transmission gears and shafts.

c. Provide a means of changing gear ratio.

d. Transmit power from the transmission to the propeller shaft.

? ?

NOTE: If you have any difficulty in matching the above items to their purposes you should go back through the material again.

PREPARE THE MAN

PROGRAMMED TEXT
3ABR47232-PT-501
3ABR47230-PT-404
3ABR47231A-PT-404C
3ABR47231B-PT-404C
3ABR47231C-PT-404C
3ABR47231D-PT-404C

Technical Training

8-11

General Purpose Vehicle Mechanic
Base Vehicle Equipment Mechanic
Special Vehicle Mechanic
(Crash/Fire Vehicles)
(Refueling Vehicles)
(Materials Handling Vehicles)
(Towing and Servicing Vehicles)

CLUTCH PRINCIPLES

17 February 1976

USAF SCHOOL OF APPLIED AEROSPACE SCIENCES
3340th Technical Training Group
Chanute Air Force Base, Illinois

Designed For ATC Course Use

DO NOT USE ON THE JOB

OBJECTIVES

When you have completed this text, you will be able to accomplish the following objectives to 85% accuracy:

1. Given a list of statements concerning clutches, select those that best describe its purpose.

2. Given a list of statements concerning clutch elements, select the statements that list the principle parts of a clutch.

3. Given a list of statements concerning the types of clutches, select those that describe the single-plate clutch, the double-plate clutch, and the multiple-disc clutch.

4. Given a list of clutch elements and a list of clutch element functions, match the correct function to each clutch element.

INSTRUCTIONS

This lesson presents information in small steps. Each page or "frame" contains an information panel and/or questions pertaining to information contained in the panel. Read the information presented, then select the correct statement in response to the question asked.

After you have selected an answer to a question and you have recorded that answer in the booklet, you may check the accuracy of your selection by turning to the last frame of this program (Confirmation Frame).

There is no time limit on this lesson. TAKE YOUR TIME. You may now proceed to Frame 1 and begin.

Supersedes 3ABR47330-PT-501, 25 February 1972.
OPR: TWS
DISTRIBUTION: X
TWS - 400; TTVGC - 1

CLUTCH PRINCIPLES

The purpose of a clutch in an automotive vehicle is to provide a means of connecting and disconnecting the engine and transmission. The engine and transmission must be connected to transmit power from the engine to the transmission. The mechanisms of the clutch allows this connection to be made gradually for smooth starts. The engine and transmission must be disconnected from each other in order to shift the transmission to various gears without stopping the vehicle.

QUESTION 1.

What is the purpose of an automotive clutch?

a. To connect and disconnect the transmission from the differential.

b. To connect and disconnect the engine from the differential.

c. To connect and disconnect the transmission from the rear driving axle.

d. To connect and disconnect the engine from the transmission.

To put a vehicle in motion from a dead stop, engine torque (twisting force) must be developed (by "reving" up the engine) with the engine and transmission disconnected from each other. Without the use of the clutch this could not be done. The mechanisms of the clutch allow the connection to be made gradually and smoothly to avoid excessive shock loads to the vehicle drive train.

QUESTION 2.

Besides providing a means of connecting and disconnecting the engine from the transmission, the clutch must also provide a means of

a. developing engine torque with the vehicle standing still and the transmission in gear.

b. smoothly applying engine torque to the rest of the drive train.

c. both a. and b. above.

d. neither a, nor b.

An automotive clutch is usually located directly behind the engine. It will always be located at some point in the power train between the engine and transmission.

QUESTION 3.

Fill in the blank space with the correct answer.

The automotive clutch is always located between the (a) ____________

and the (b)___________.

All automotive clutches depend on friction for their operation, either solid friction as in the conventional clutch, or fluid friction as used in the clutching mechanisms of automatic transmissions. The remainder of this lesson will be concerned with conventional clutches.

QUESTION 4.

On what does a conventional clutch depend for operation?

a. Solid friction.

b. Fluid friction.

c. Inertia.

Conventional clutches are devided into two different types of components or members - Drive Members and Driven Members.

Drive members are those which are connected to the engine. Driven members are those which are connected to the transmission. The majority of general purpose vehicle clutches utilize two drive members and one driven member.

Power is transferred from the engine to the transmission through the clutch by bringing the driving members into gradual contact with the driven member.

QUESTION 5 through 8.

Fill in the blank spaces with the correct answer.

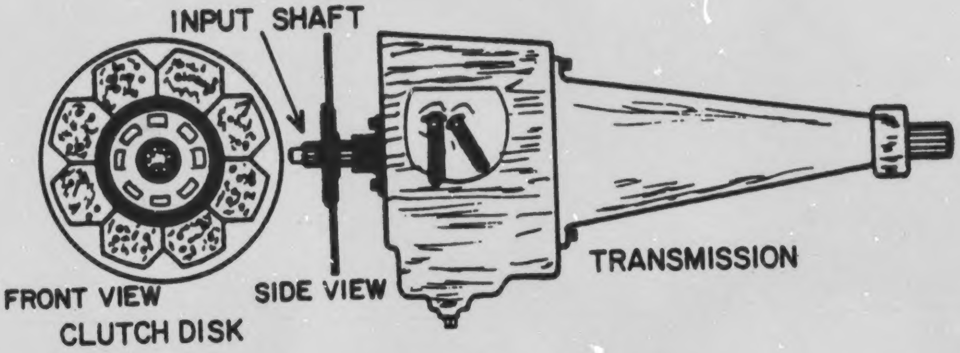
5. The (a)____________ and the (b)________________ are the two types of members used in conventional clutches.

6. Drive members are those which are connected to the _______________.

7. ______________ members are those which are connected to the transmission.

8. Power is transferred from the engine to the transmission through the use of a __________________.

The driven member of the conventional clutch is a disc with a hub in the center which is splined to the transmission input shaft, but is free to slide lengthwise along the shaft. It is called the clutch disc. When the clutch disc is driven or turned, it drives the transmission input shaft.

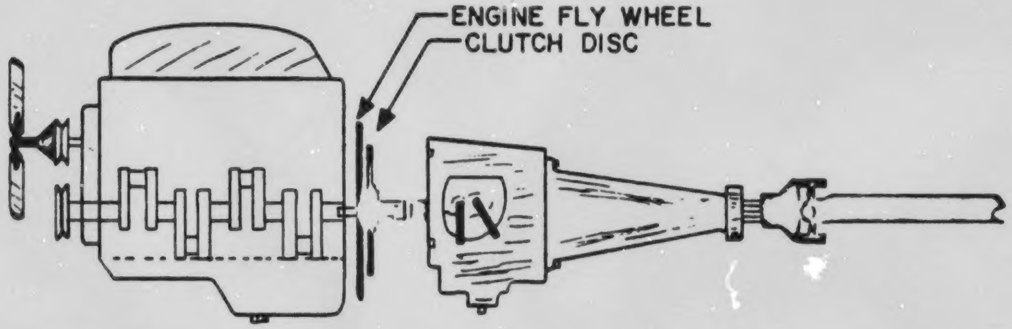

INPUT SHAFT
TRANSMISSION
FRONT VIEW
SIDE VIEW
CLUTCH DISK

QUESTION 9.

Fill in the blank spaces with the correct answers.

The driven member of the conventional clutch is called the (a)__________ __________, and it is splined to the (b) ____________ ____________ ____________.

One of the drive members is the engine flywheel. When the driven member (clutch disc) is bought into contact with the flywheel, the friction between the two causes the clutch disc to rotate in the same direction as the flywheel. The rotation of the disc consequently rotates the input shaft of the transmission to which it is splined.


ENGINE FLY WHEEL
CLUTCH DISC

QUESTION 10.

The principle which enables the clutch to transmit power from the engine to the transmission is

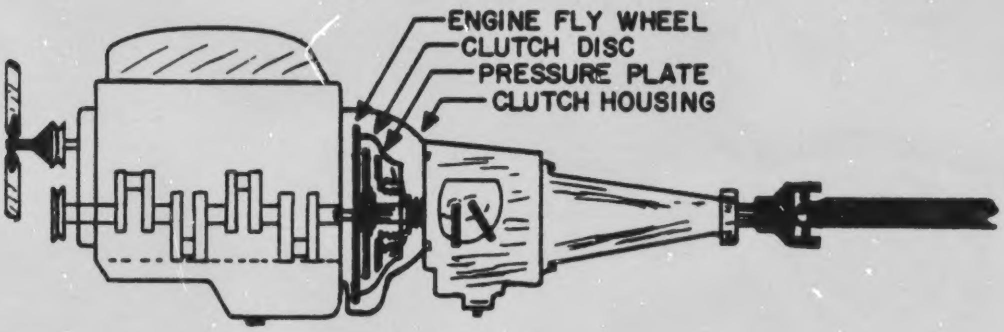
a. power.

b. torque.

c. friction.

d. pressure.

The second drive member is called a pressure plate. The pressure plate is bolted to the flywheel and therefore turns with the flywheel whenever the engine is running. It is the pressure plate which forces the clutch disc to contact the flywheel when the engine and transmission are connected. When the engine and transmission are connected, we say the clutch is engaged.



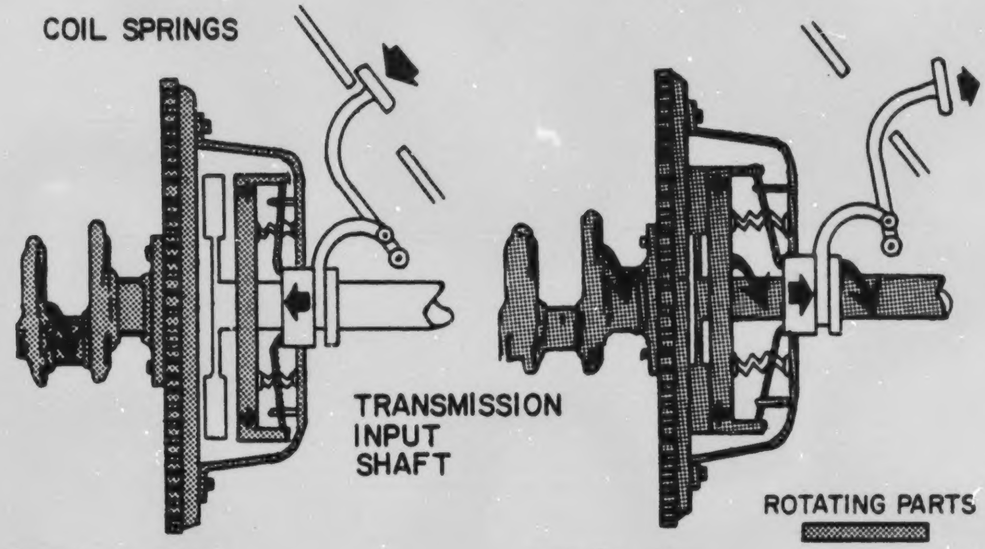
QUESTION 11 and 12.

Fill in the blank space with the correct answer.

11. The two drive members of a conventional clutch are the (a) ______ and the (b) ______________ ______________.

12. When the engine and transmission are connected, we say the clutch is ____________________.

Contact between the rotating drive members and the driven member is established and maintained by strong spring pressure from springs or other devices located in the pressure plate. This spring pressure is controlled by the vehicle operator through the clutch pedal and suitable linkage. As spring pressure is gradually allowed to release, the friction between the drive and driven member increases; until there is no slippage between the drive and driven members. When the pressure is light, the comparatively small amount of friction between the drive and driven members permits a great deal of slippage.



PEDAL DOWN, CLUTCH DISENGAGED

PEDAL UP, CLUTCH ENGAGED

QUESTION 13.

How is the friction between the drive and driven members of the clutch controlled?

- a. Through automatic spring pressure in the clutch members.
- b. By the vehicle operator through the use of a clutch pedal and and suitable linkage.
- c. By using a clutch spring regulator and linkage adjuster.
- d. By shifting the transmission into a lower ratio gear.

We stated in the last information panel that friction between the members increases with spring pressure and decreases with less spring pressure. There is a reason for this. You will recall from previous information that the clutch must be engaged smoothly and gradually to prevent excessive shock in the power train components. When friction is first obtained between the drive and driven members of the clutch, the vehicle will start to "creep" even though there is a great deal of slippage. The engine cannot transmit its maximum power to the transmission until maximum friction is obtained between the clutch members. That is, when all slipping has stopped and there is a direct connection between the driving and driven parts.

QUESTIONS 14 through 16.

14. Under what condition will all power produced by the engine be applied to the transmission?
    - a. When the driving and driven clutch members have minimum friction.
    - b. When maximum spring pressure is applied to the clutch members.
    - c. When the clutch is slipping at its minimum.
    - d. When the vehicle is beginning to "creep."
15. When will a vehicle begin to creep?
    - a. When the clutch is first disengaged.
    - b. When the clutch is fully disengaged.
    - c. When the clutch is fully engaged.
    - d. When the clutch is partially engaged.
16. Why is it necessary to gradually and slowly engage the clutch of a vehicle?
    - a. To create less friction.
    - b. To create maximum friction.
    - c. To minimize power train shock.
    - d. To start a vehicle moving suddenly.

CLUTCH ELEMENTS

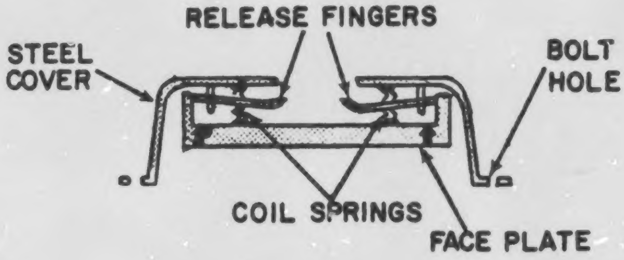
In the next few frames of this lesson we will be discussing the principal parts of various clutches. You will be shown some pictures and diagrams of typical clutches. There are literally dozens of different makes and models of clutches but we will try to familiarize you with typical clutches.

Although this lesson teaches you clutch fundamentals, it will be necessary for you to consult a shop manual or a technical order for information on a specific type and model of clutch.

This lesson is based on information contained in TO 36A-1-76.

The driving members of a clutch assembly usually consist of two cast iron plates or flat surfaces machined and ground to a smooth finish. Cast iron is desirable because it contains enough graphite to provide some lubrication when the driving member is slipping during initial engagement. One of these surfaces is usually the rear face of the flywheel and the other is a comparatively heavy flat ring having one side machined and surfaced. This latter part is known as the "pressure plate." It is fitted into a steel cover, which also contains some of the operating members, and is bolted to the flywheel.

TYPICAL SPRING TYPE PRESSURE PLATE



QUESTION 17.

What part of the clutch is made of cast iron and is attached to the engine flywheel?

a. Driven member.

b. Pressure plate.

c. Operating member.

d. Clutch disc.

QUESTION 18.

Why would a pressure plate made of cast iron be more desirable?

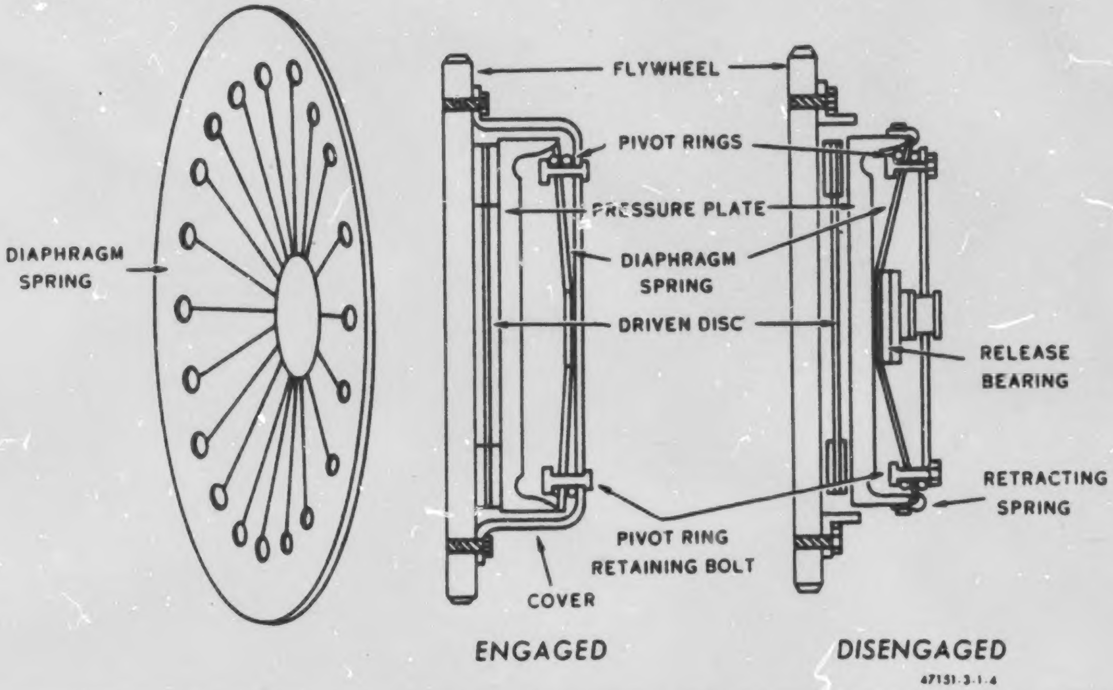
a. Because a cast iron surface can be ground more smoothly.

b. Because of its self-lubricating characteristics.

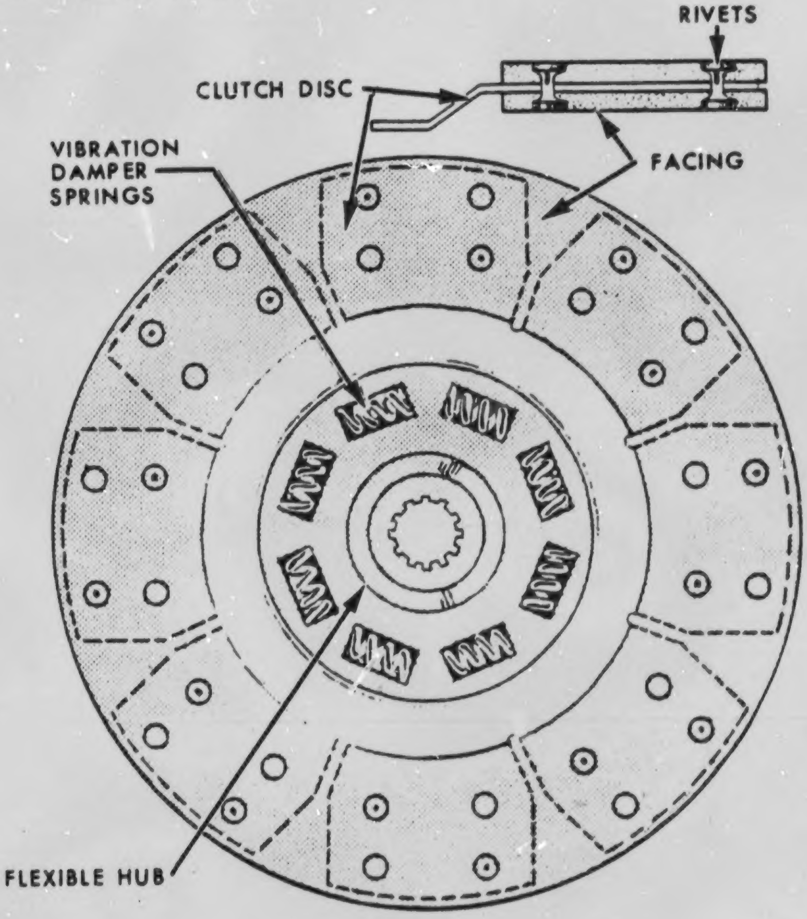
c. Because cast iron minimizes slippage.

d. Because cast iron is comparatively heavy.

Some pressure plates use no springs, but instead use a single cone shaped disc for applying thy pressure to the driven member. This type of disc "spring" works on the same principle as the spring button of an oil can. When pressed in the middle, the outside edges retract, pulling the driving plate of the pressure plate away from the driven member (clutch disc). As in the illustration below.


DIAPHRAGM SPRING
FLYWHEEL
PIVOT RINGS
PRESSURE PLATE
DIAPHRAGM SPRING
DRIVEN DISC
RELEASE BEARING
RETRACTING SPRING
PIVOT RING RETAINING BOLT
COVER
ENGAGED
DISENGAGED
47131-3-1-4

The clutch disc is usually made of spring steel in the shape of a single flat disc of a number of flat segments. Suitable frictional facings are attached to each side of the disc with copper rivets. These facings must be heat-resistant since friction produces heat. The most commonly used facings are made of cotton and asbestos fibers. These materials are woven or molded together and impregnated with resins or similar bonding agents. Very often, copper wires are woven or pressed into the material to give it additional strength. The figure below shows a typical clutch disc.



QUESTION 19.

Why is it necessary to face the clutch disc with heat-resistant material?

a. Because the disc is exposed to great amounts of friction which produces heat.

b. Because the clutch disc is constantly slipping which creates a great amount of heat.

c. Because the disc is located in such a place that it receives a great amount of engine heat.

The clutch disc is provided with a flexible center which absorbs the torsional vibration of the crankshaft. The flexible center usually takes the form of steel compression springs placed between the hub and the steel disc. The springs permit the disc to rotate slightly backward as the springs decompress. This slight backward and forward rotation permitted by the springs allows the clutch shaft to rotate at a more uniform rate than the crankshaft, thereby preventing some of the torsional vibration of the crankshaft from being transmitted to the drive.

QUESTION 20.

What is the purpose of the flexible center on a clutch disc?

a. To absorb excessive vehicle road shock.

b. To absorb torsional vibration of the crankshaft.

c. To absorb torsional vibration of the transmission.

d. To absorb torsional vibration of the pressure plate.

In order to make clutch engagement as smooth as possible and to eliminate "chatter," several methods have been used to provide a little flexibility to the clutch disc. One type of disc is "dished," so that the inner and outer surfaces of the friction facing make contact gradually as spring pressure is increased and the disc flattens out.

QUESTION 21.

What is the purpose of "dishing" a clutch disc?

a. To eliminate chatter and make engagement sudden.

b. To make the entire surface of the disc contact the driving members immediately upon engagement.

c. To eliminate chatter and make clutch engagement smooth by allowing the inner and outer edges of the disc to make contact with the driving members gradually.

TYPES OF CLUTCHES

Automotive clutches may be classified according to the number of plates or discs used. The single-plate clutch contains one driven disc operating between the flywheel and the pressure plate. The flywheel is not considered to be a plate, even though it acts as one of the driving surfaces.

QUESTION 22.

A clutch containing one driven disc operating between the flywheel and the pressure plate is referred to by what name?

a. Single-plate clutch.

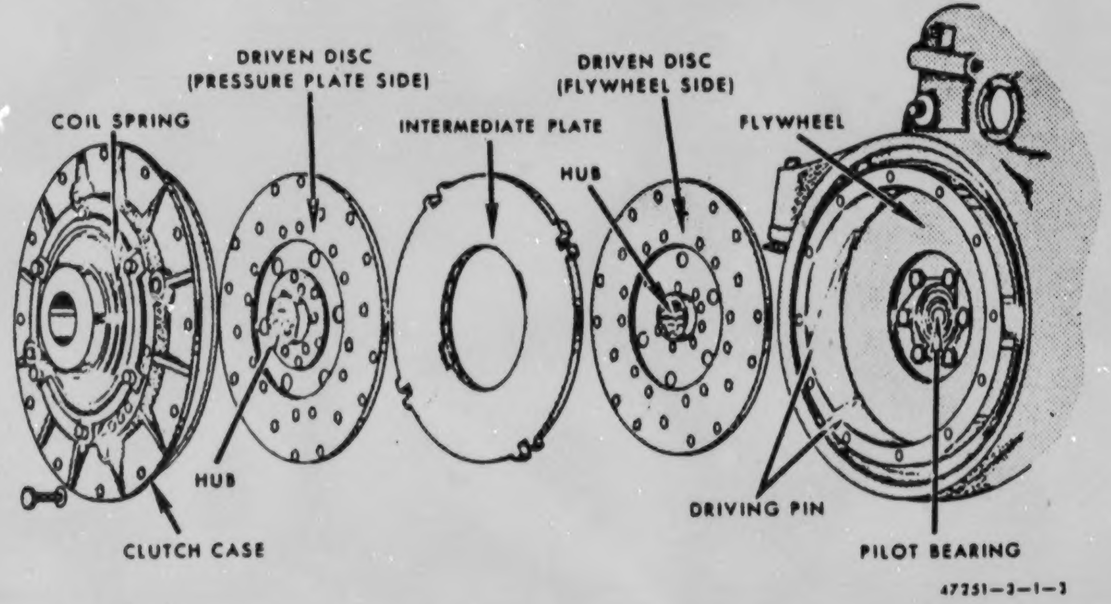
b. Double-plate clutch.

c. Multiple-disc clutch.

d. All of the above.

A double-plate clutch is substantially the same as the single-plate clutch except that another driven disc and an intermediate driving plate are added. The principle of operation of both clutches is basically the same.

The illustration below depicts a double-plate type clutch. Observe that it has two driven discs and an intermediate plate.


DRIVEN DISC (PRESSURE PLATE SIDE)
COIL SPRING
INTERMEDIATE PLATE
DRIVEN DISC (FLYWHEEL SIDE)
HUB
FLYWHEEL
HUB
CLUTCH CASE
DRIVING PIN
PILOT BEARING
47751-3-1-3

QUESTION 23.

What components make up the double-plate clutch?

a. Two driven discs and no driving plate.

b. One intermediate driving plate and one driven disc.

c. Two intermediate driving plates and two driven discs.

d. Two driven discs and an intermediate driving plate.

A clutch having four or more driven discs is referred to as a multiple-disc clutch. Again, the principle of operation is essentially the same as the single plate and thy double-plate clutch.

QUESTION 24.

How many driven discs does a multiple-disc clutch have?

a. One.

b. Two.

c. Three.

d. More than three.

INSTRUCTIONS:

Match the numbered statement or phrase on the left with the lettered statement or phrase on the right.

QUESTIONS 25 through 28.

25. Maximum spring pressure is applied to the clutch members.

26. Connects and disconnects the engine and transmission of a vehicle.

27. A clutch depends on this for its operation.

28. Drive members, driven members, springs, and linkage.

29. Gradually and smoothly engage the clutch of a vehicle.

a. Solid friction.

b. Minimize power train shock.

c. Clutch.

d. Maximum engine power is applied to the transmission.

e. Principal parts of the clutch.

QUESTIONS 25 through 33.

30. Two driven discs and an intermediate driving plate.

31. One driven disc operating be tween the flywheel and the pressure plate.

32. Spring steel in the shape of a single flat disc or a number of flat segments.

33. Two cast iron plates machined and ground to a smooth finish.

34. Eliminates clutch chatter and makes engagement smooth by allowing members to contact gradually.

a. Clutch disc.

b. Pressure plates.

c. Double-plate clutch.

d. "Dishing" a clutch plate.

e. Single-plate clutch.

CONFIRMATION PANEL

You may use this confirmation panel at any time in order to check the accuracy of your work as you progress through this lesson.

QUESTION NUMBER	ANSWER	QUESTION NUMBER	ANSWER
1	d	29	b
2	c	30	c
3a	transmission	31	e
3b	engine	32	a
4	A	33	b
5a	drive	34	d
5b	driven		
6	engine		
7	driven		
8	clutch		
9a	clutch disc		
9b	transmission input shaft		
10	c		
11a	flywheel		
11b	pressure plate		
12	engaged		
13	b		
14	b		
15	d		
16	c		
17	b		
18	b		
19	a		
20	b		
21	c		
22	a		
23	d		
24	d		
25	d		
26	c		
27	a		
28	e		

372

PREPARE THE MAN

PROGRAMMED TEXT 3ABR47~~330~~232-PT-501B
3ABR47231-1-PT-404
3ABR47231A-PT-404
3ABR47231B-PT-404
3ABR47231C-PT-404
3ABR47230-PT-502A

Technical Training

General Purpose Vehicle ~~Repairman~~ Mechanic
Special Vehicle Repairman
(Towing & Servicing Vehicles)
(Crash/Fire Vehicles)
(Refueling Vehicles)
(Materials Handling Vehicles)
Base Maintenance Equipment Repairman

8-11

POWER TAKEOFF

30 May 1974

CHANUTE TECHNICAL TRAINING CENTER (ATC)

This supersedes 3ABR47330-PT-501B, 3ABR47231-1-PT-603, 3ABR47231A-PT-603, 3ABR47231B-PT-603, 3ABR47231C-PT-603, 17 August 1972.
OPR: TWS
DISTRIBUTION: X
TWS - 200; TTOC - 7

Designed For ATC Course Use

DO NOT USE ON THE JOB

OBJECTIVES

Upon completion of this programmed text you will be able to accomplish the following objectives with 85% accuracy.

1. Given statements about power takeoff units, select those that best describe their purpose and location.

2. Given a diagram of a power takeoff unit and a list of component names, match the component with its proper name.

3. Given a power takeoff unit, proper tools and task list, disassemble, inspect and reassemble the power takeoff unit.

VALIDATION

This programmed text was validated by students enrolled in the 3ABR47330 Course in 1964 and has proved successful since that time.

INSTRUCTIONS

This lesson presents information in small steps. Each page or "frame" contains an information panel and/or questions pertaining to information contained in the last panel. Read the information presented within the solid-lined box, identified by a closed or open book, then select the correct statement in response to the question asked in the question-mark outlined box. DO NOT WRITE IN THIS BOOKLET. Mark all answers on the answer sheet you have been provided with (ATC Form 26A). After you have selected an answer to a question, you may check the accuracy of your selection by turning to Frame 9. Do not look at the confirmation frame (Frame 9) until you have made your selection of the answer.

You may consult your instructor at any time.

You may now proceed to Frame 1 and begin. There is no time limit on this lesson.

Some vehicles are equipped with accessories which are dependent on part of the vehicle drive train for their power. An example of this would be a winch. We have all seen winches on the front of trucks and wreckers, but how often have we given any thought to how these winches are operated?

Winches depend on a power take-off as a source of their power. This means, then, that a power take-off is an attachment used to connect the engine of a vehicle to power-driven auxiliary units.

QUESTION 1.

? ?

? What is the purpose of a power take-off? ?

? a. To connect the engine of a vehicle to power-driven auxiliary units. ?

?

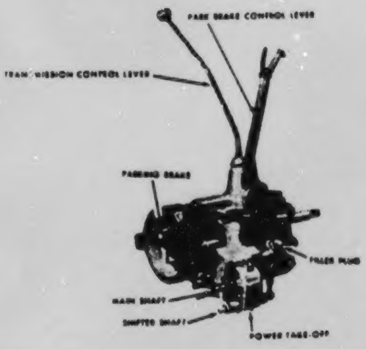
b. To drive winches only.

? ?

? ?

Frame 2.

Because power take-offs are used to connect a vehicle engine to other power-driven auxiliary units, they are usually attached to the main transmission or auxiliary transmission of a vehicle. In the illustration below, the power take-off is attached to the transmission and is used to drive the winch.


PARK BRAKE CONTROL LEVER
TRANSMISSION CONTROL LEVER
PARKING BRAKE
FILLER PLUG
MAIN SHAFT
SHIFTER SHAFT
POWER TAKE-OFF

QUESTION 2.

? ?

? To what unit of a vehicle is the power take-off usually attached? ?

? a. Differential. ?

? b. Auxiliary transmission. ?

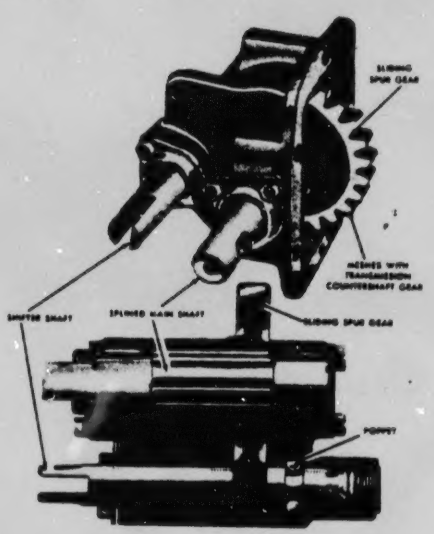
? c. Transmission. ?

? d. Winch. ?

? ?

Frame 3.

Now we understand that power take-offs connect a vehicle engine with power-driven auxiliary units and they are normally connected to the vehicle transmission. How about their operation? Study the diagram below, then answer the question below concerning the operation of a power take-off.


SLIDING SPUR GEAR
MESHES WITH TRANSMISSION COUNTERSHAFT GEAR
SHIFTER SHAFT
SPLINED MAIN SHAFT
SLIDING SPUR GEAR
POPPET

QUESTION 3.

? ?

? Which of the following statements best describes the operation of a power take-off? ?

? ?

a. A power take-off is a manually-engaged, gear-driven unit.

? ?

b. A power take-off is a manually-engaged, hydraulically-operated unit. ?

? ?

Frame 4.

As you can probably tell, the power take-off shown in Frame 3 is a single-gear unit. This is the simplest type of power take-off. This type of power take-off is usually bolted to the side of the transmission. An opening is provided in the transmission case for this purpose by the manufacturer. Another interesting feature of the single-gear power take-off is that it is manually engaged.

QUESTION 4.

? ?

Select the statement below which best sums up all that you have learned about power take-offs.

a. The simplest type of power take-off is a single-gear, manually engaged unit that operates off the vehicle differential.

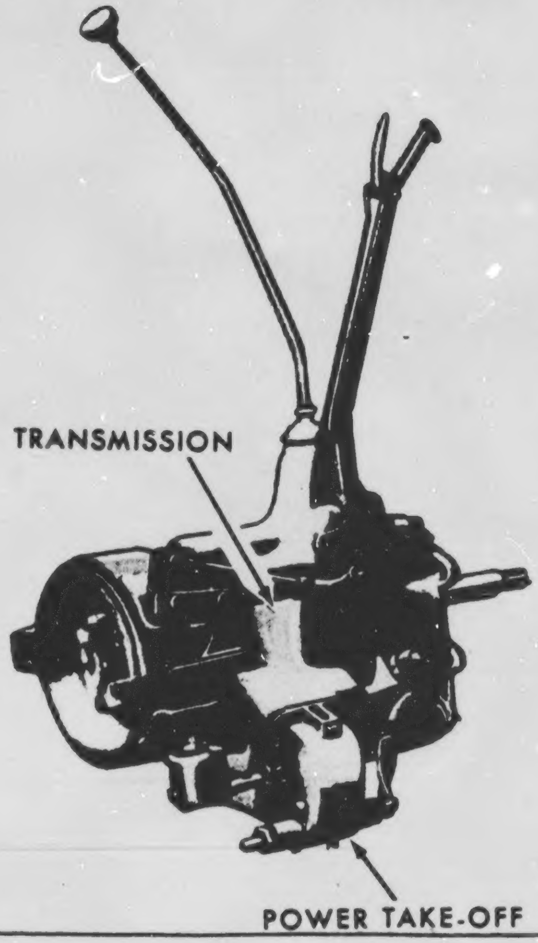
b. The simplest type of power take-off is a single-gear, manually engaged unit that is bolted to the transmission and connects the vehicle's engine to the auxiliary units.

c. The simplest type of power take-off is a single-gear, hydraulically operated unit that generates its own power.

? ?

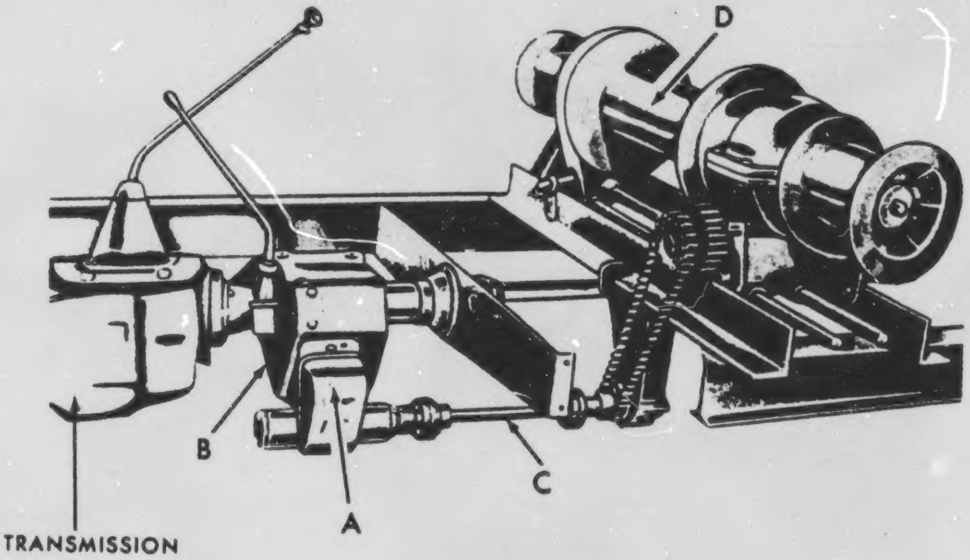
Although we have been discussing only one type of power take-off, there are many different types and styles. Some are multiple-gear and multi-speed. Some even depend on auxiliary transmissions for their power. The next few diagrams will show you some of these different power take-offs and their applications to specific units. These pictures and diagrams will be for your familiarization only.

The diagram below shows a single-speed, single-gear power take-off like the kind you have been studying. Note its size in relation to that of the transmission.


TRANSMISSION
POWER TAKE-OFF

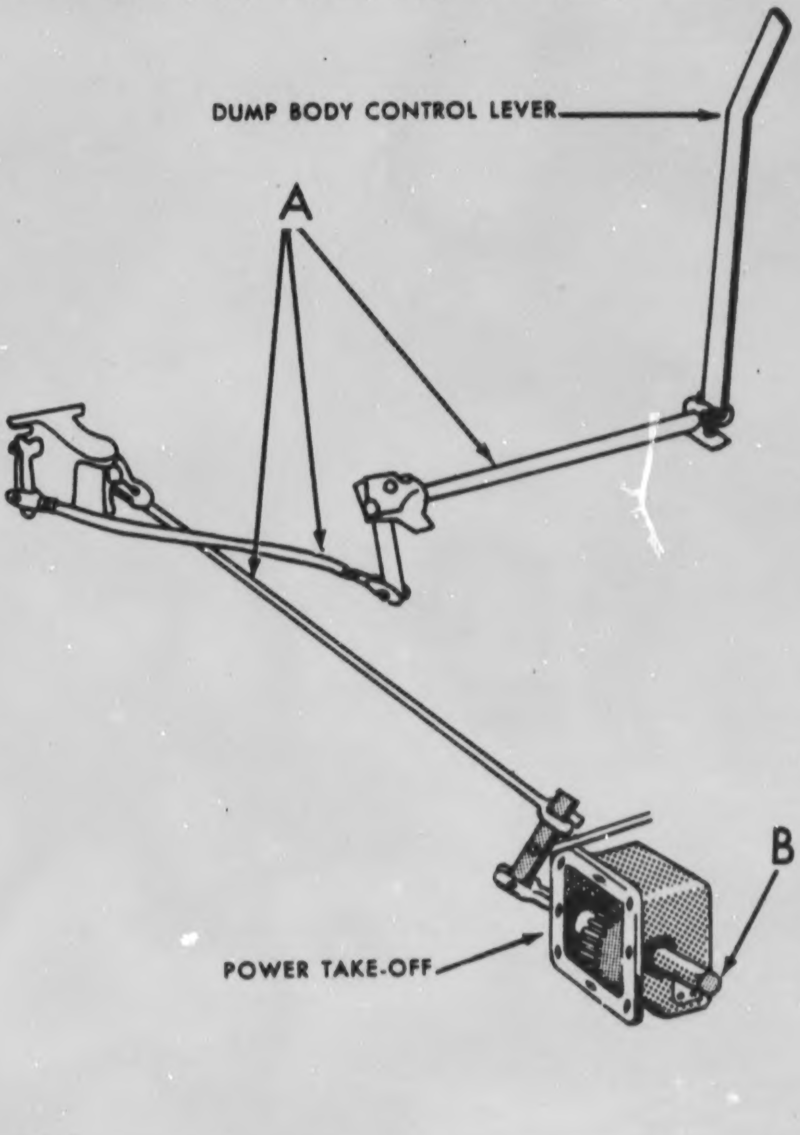
Frame 6.

Here you see a power take-off (Item "A") attached to an auxiliary transmission (Item "B") being used to drive a winch. Notice that the power take-off transfers power through a propeller shaft (Item "C") to the winch (Item "D").



Frame 7.

This is a much more complex type of power take-off. Notice. however, the control linkage (Item "A"). This particular type of power take-off is used to operate a dump truck. The power take-off is attached to the truck's transmission and the output shaft of the power take-off (Item "B") drives the hydraulic dump mechanism.


DUMP BODY CONTROL LEVER
A
B
POWER TAKE-OFF

Frame 8.

There aren't many moving parts in a single-speed, single-gear power take-off, but it is necessary that you be able to recognize them. Inside the power take-off case you will find one gear (Item "A") which, when moved with the shifter shaft (Item "C"), meshes with a gear in the vehicle's transmission. When the power take-off gear, technically called the "sliding spur gear," is meshed with the vehicle's transmission the main shaft (Item "B") is put into motion. This means that the main shaft is connected directly to the sliding spur gear.

QUESTIONS 5, 6, and 7.

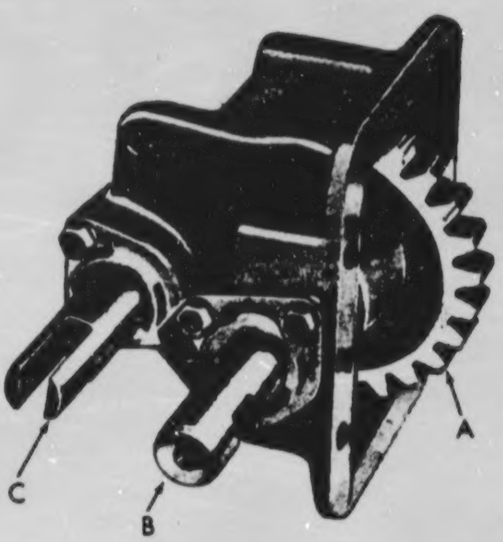
? ?

? Blacken the space on your answer sheet that matches the name of the ?
component as given below on the left with that component in the
? diagram below. ?

? 5. Sliding spur. ?

? 6. Shifter shaft. ?

? 7. Main shaft. ?



? ?

CONFIRMATION PANEL

You may use these answers to check the accuracy of your responses to the questions asked in the lesson.

Answer #1 is a.

Answer #2 is c.

Answer #3 is a.

Answer #4 is b.

Answer #5 is a.

Answer #6 is c.

Answer #7 is b.

PREPARE THE MAN

PROGRAMMED TEXT 3ABR47~~330~~z32-PT-503
3ABR47231-1-PT-603A
3ABR47231A-PT-603A
3ABR47231B-PT-603A
3ABR47231C-PT-603A
3ABR47230-PT-502

Technical Training

General Purpose Vehicle ~~Repairman~~ mechanic
Special Vehicle Repairman
(Towing and Servicing Vehicles)
Special Vehicle Repairman
(Crash/Fire Vehicles)
Special Vehicle Repairman
(Refueling Vehicles)
Special Vehicle Repairman
(Materials Handling Vehicles)
Base Maintenance Equipment Repairman

8-11

DRIVE TRAIN COMPONENTS

2 January 1974

CHANUTE TECHNICAL TRAINING CENTER (ATC)

This supersedes 3ABR47330-PT-503, 3ABR47231-PT-603A, 3ABR47231A-PT-603A, 3ABR47231B-PT-603A, 3ABR42731C-PT-603A, 15 August 1972.
OPR: TWS
DISTRIBUTION: X
TWS - 575; TTOC - 7

Designed For ATC Course Use

DO NOT USE ON THE JOB

OBJECTIVES

While most vehicles are designed to operate over relatively smooth hard-surfaced roads, some vehicles must be able to operate efficiently over all types of terrain. These vehicles are equipped to transmit power to all wheels. This power is transmitted through the use of: transfer cases, Sprag units, propeller shafts and universal joints, center bearings, and pillow blocks. In addition, some vehicles are equipped with a cable winch which is powered by a power take-off. These are the units that this lesson is all about. When you have finished with this program, you will be able to:

1. Select the correct answers to multiple-choice type questions about the purpose and operating principles of universal joints, propeller shafts, center bearings, transfer cases, Sprag units, winches, and pillow blocks.
2. Locate and identify these units on an illustration.
3. Locate information on the construction features of these components and their removal, disassembly, inspection, repair, reassembly, and installation.
4. Disassemble, inspect, and reassemble universal joints, center bearings, and transfer cases.
5. Operate and adjust a winch.
6. Inspect a propeller shaft for serviceability.

These must be accomplished with 80% accuracy.

VALIDATION

This programmed text was validated by students enrolled in the 3ABR47330 Course in 1964 and has proved to be successful since that time.

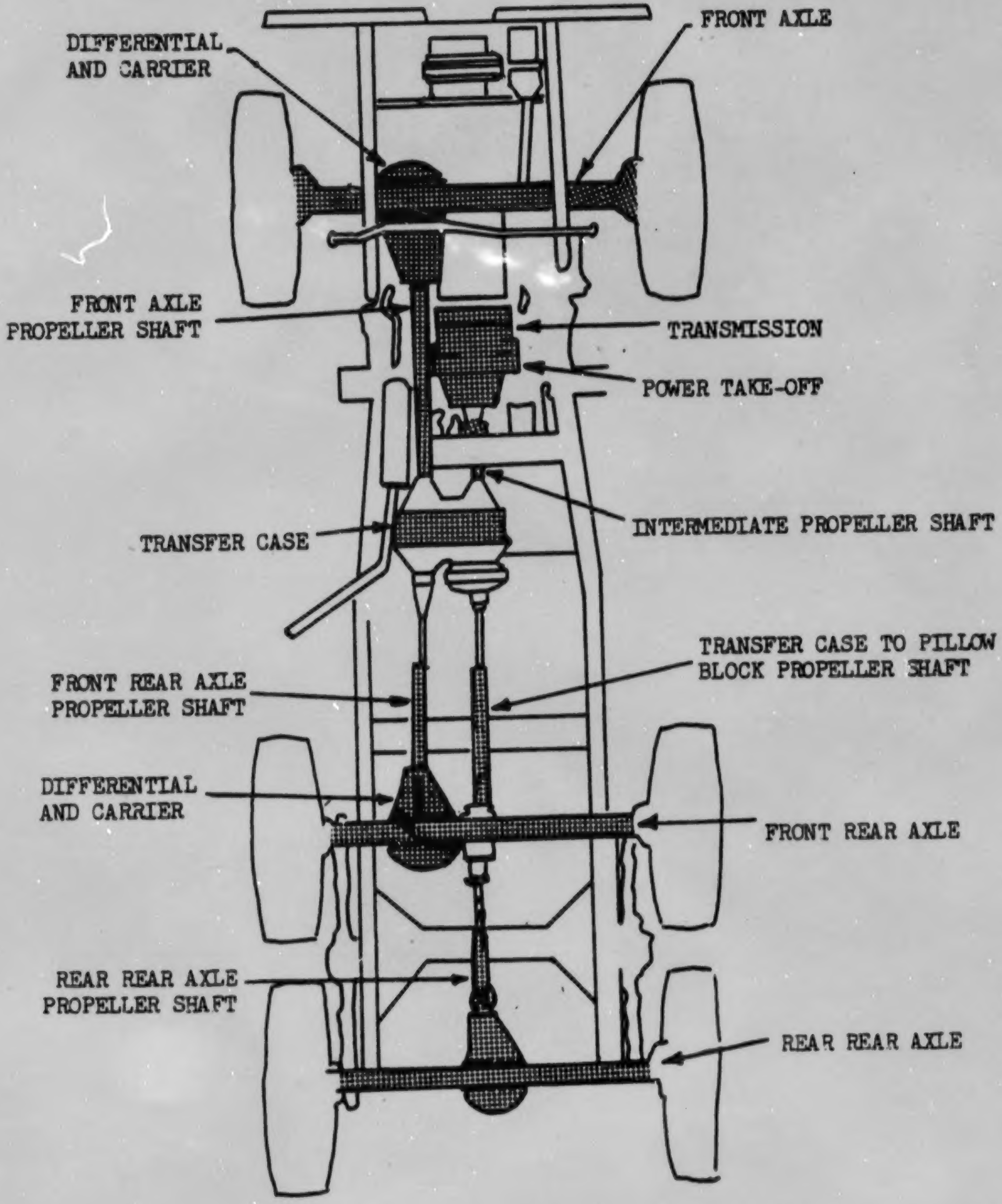
INSTRUCTIONS

The material to be presented in this program is broken up into small units called "frames." Each frame contains an information section and/or an illustration panel presenting information that is to be learned. Following each information panel there will generally be presented a question or two. Indicate your choice of the correct answer by BLACKING OUT the letter on the Standard Answer Sheet that corresponds to your choice of the correct choice for each question. For confirmation of your response, refer to the top of the next frame where the correct answer(s) will be given.

Proceed to the next page and start with Frame 1. Study the illustration carefully before turning to the information presented in Frame 2.

Frame 1.

ILLUSTRATION PANEL


DIFFERENTIAL AND CARRIER
FRONT AXLE
FRONT AXLE PROPELLER SHAFT
TRANSMISSION
POWER TAKE-OFF
INTERMEDIATE PROPELLER SHAFT
TRANSFER CASE
TRANSFER CASE TO PILLOW BLOCK PROPELLER SHAFT
FRONT REAR AXLE PROPELLER SHAFT
DIFFERENTIAL AND CARRIER
FRONT REAR AXLE
REAR REAR AXLE PROPELLER SHAFT
REAR REAR AXLE

Frame 2.

In order to deliver engine torque to more than one driving axle, an auxiliary gear train called a "transfer case" is used. A transfer case differs from a transmission in that it has two or more output shafts, while a transmission has only one. The illustration provided in Frame 1 depicts a wormseye view of a six-wheel drive truck, commonly called a "six-by-six." Turn back to Frame 1 and locate the transfer case, then answer the two following questions.

QUESTIONS 1 and 2.

? ?

? 1. In the figure shown in Frame 1, the transfer case distributes power to how many driving axles? ?

?

a. 1.

b. 2.

c. 3.

?

? 2. The purpose of the transfer case is to distribute power to ?

? a. one driving axle. ?

? b. two or more driving axles. ?

?

? ?

Answers to previous questions:

1. 3 axles (response "c").
2. b.

There are two types of transfer cases: single speed and two speed. The single speed transfer case contains a drive gear, idler gear, and driven gear, mounted on shafts and bearings. This type of transfer case is usually installed in vehicles that are equipped with automatic transmissions.

The two speed transfer case contains a drive gear, idler gear, driven gear, plus a sliding gear, and a low speed gear, all of which are mounted on shafts and bearings. The two speed transfer case is installed in vehicles that are equipped with manual transmissions.

On Frames 4 and 5 there are two illustrations. Study them carefully, then answer the questions below.

QUESTIONS 3 and 4.

? ?

3. Which Frame illustrates a single speed transfer case?
   a. Frame 4.
   b. Frame 5.
4. Which wheels of the vehicle are in constant drive with the transfer case?
   a. Front.
   b. Rear.
   c. Both.
   d. Neither.

? ?

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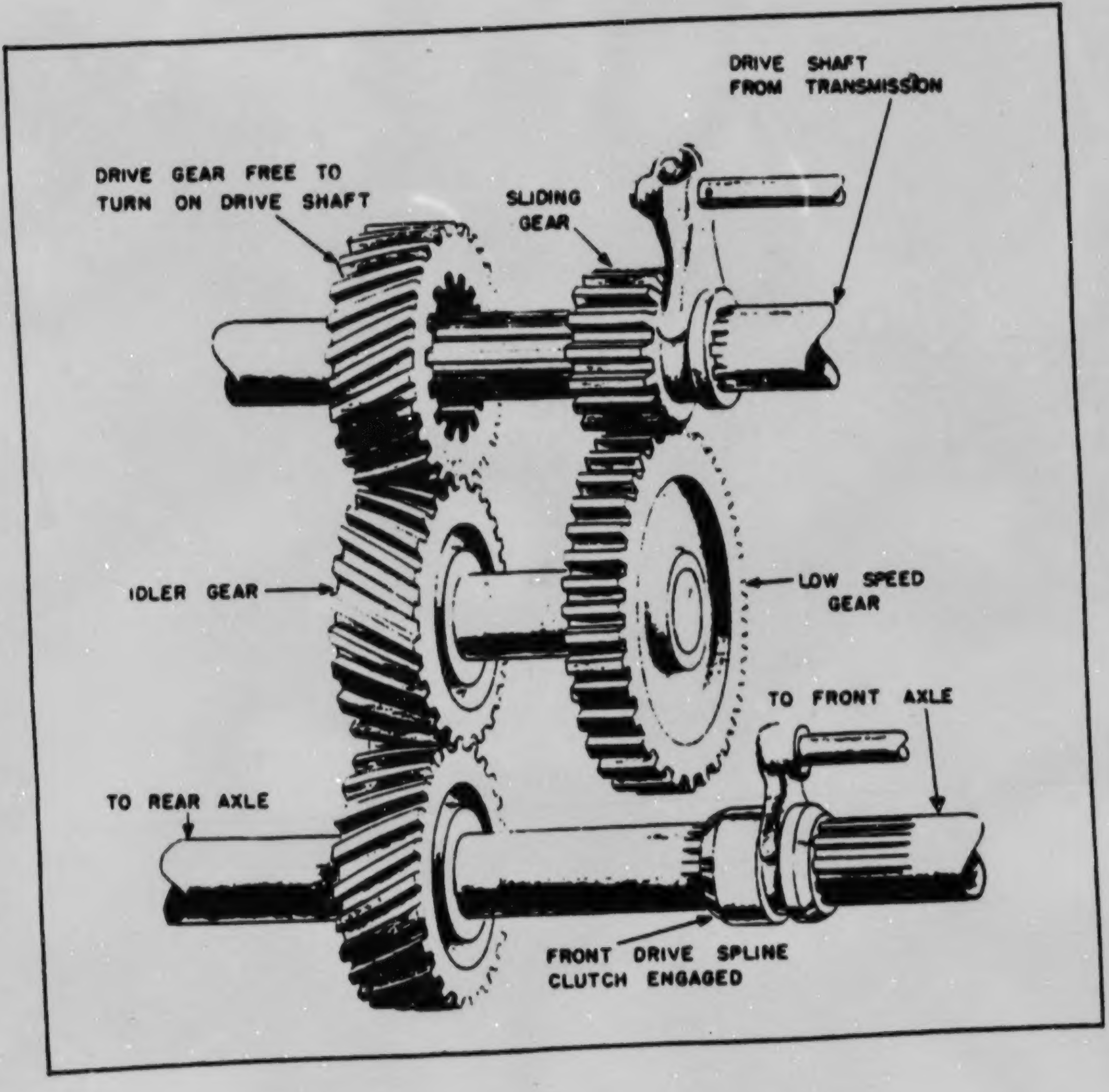
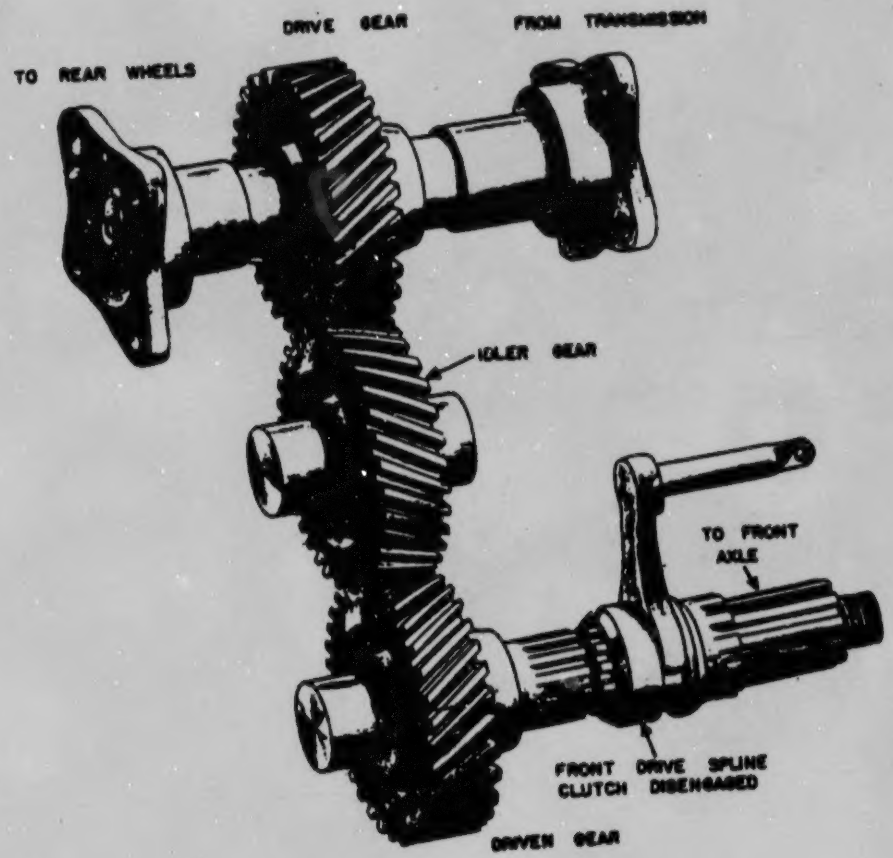
Frame 4.


DRIVE SHAFT FROM TRANSMISSION
DRIVE GEAR FREE TO TURN ON DRIVE SHAFT
SLIDING GEAR
IDLER GEAR
LOW SPEED GEAR
TO FRONT AXLE
TO REAR AXLE
FRONT DRIVE SPLINE CLUTCH ENGAGED

Frame 5.


DRIVE GEAR
FROM TRANSMISSION
TO REAR WHEELS
IDLER GEAR
TO FRONT AXLE
FRONT DRIVE SPLINE CLUTCH DISENGAGED
DRIVEN GEAR

Frame 6.

Answers to previous questions:

3. Frame 5.

4. b. If the rear wheels were NOT in constant drive with the transfer case, there would be no driving action at all. If the front wheels were in constant drive, there would be no need for the transfer case.

Some transfer cases incorporate a mechanism which automatically disengages the front wheel driving action during turns since the front wheels are rotating at a different speed than the rear wheels at that time. Such disengagement helps minimize wear on the tires and strain on the gears. In this type of transfer case, the front axle sliding gear which engages and disengages the front wheel drive is replaced by an automatic declutcher. While there are many types of automatic declutchers, the only one we will discuss is the Sprag Assembly.

The Sprag Assembly is essentially a mechanism used for declutching the front wheel drive. With this unit, power is automatically applied to the front wheels when the rear wheels lose traction. When the rear wheels regain traction, the power is automatically disconnected from the front wheels.

QUESTION 5.

? ?

The purpose of the Sprag Assembly used on vehicles with front wheel drive is to

a. allow power to be applied to the front wheels when the rear wheels lose traction.

b. automatically disengage power from the rear wheels when the front wheels lose traction.

c. apply power to the front wheels when the rear wheels lose traction, and disengage it when the rear wheels regain traction.

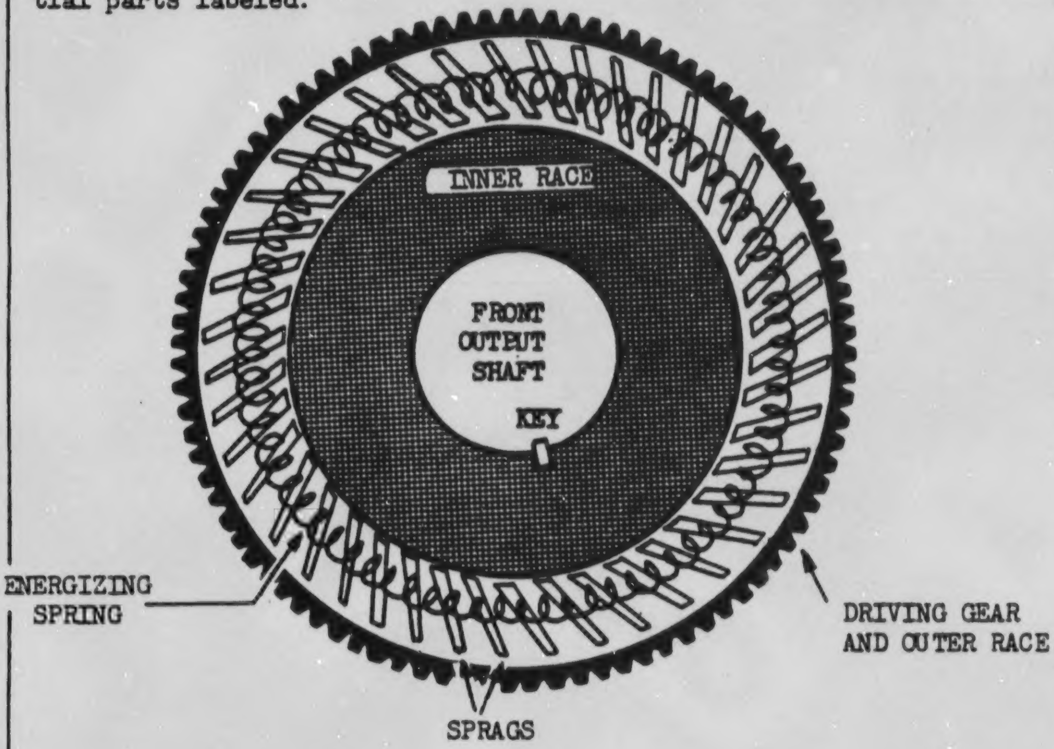
d. prevent the front wheels from spinning.

? ?

Answer to previous question:

5. c. NOTE: Response a was only partly correct since it only described half the function of the Sprag unit.

A Sprag unit consists of three main parts: the inner race, the outer race, and the Sprags or cams located between the two races. The illustration below is an end view of a Sprag unit with the essential parts labeled.


INNER RACE
FRONT OUTPUT SHAFT
KEY
ENERGIZING SPRING
DRIVING GEAR AND OUTER RACE
SPRAGS

Frame 8.

The action of the Sprags depends on the variable rotation of the races. Assume that the outer race of the Sprag unit is connected to the power output of the transfer case and that the inner race is connected to the front driving axle. When the outer race attempts to turn faster than the inner race, the Sprags pivot and lock the races together. This causes the races to rotate at the same speed and deliver power to the front driving axle. Conversely, when the outer race turns slower than the inner race, as it will when the rear wheels regain traction, the Sprags pivot and disengage. This allows the inner race to "free wheel" and power is not delivered to the front driving axle. There are two Sprags in a Sprag Assembly, a forward and a reverse Sprag unit. The forward unit is engaged when in first gear. The reverse only when the transmission is shifted into reverse gear.

QUESTIONS 6 and 7.

? ?

6. On what does the action of the Sprags depend?
   - a. The direction of rotation of the Sprags.
   - b. The variable rotation of the races.
   - c. The amount of power delivered to the front wheels.
   - d. The amount of power delivered to the rear wheels.

7. What are the three main parts of the Sprag unit?
   - a. Inner race, outer race, and clutch fingers.
   - b. Inner race, Sprags, and spring clips.
   - c. Input shaft, output shaft, and Sprags.
   - d. Inner race, Sprags, and outer race.

? ?

Answers to previous questions:

6. b.
7. d.

QUESTION 8.

? ?

? What action will cause the Sprags to pivot and lock the inner race and outer race together? ?

? a. The front wheels must turn faster than the rear wheels. ?

? b. The inner race must turn faster than the outer race. ?

? c. The rear wheels must lose traction. ?

d. The constant speed drive must be engaged.

? ?

? ?

The transfer case is mounted in the vehicle frame between the transmission and the rear axle. It receives power from the output shaft of the transmission and transfers power to the front driving axle and one or more rear driving axles. On any vehicles equipped with a transfer case, at least one rear axle is in constant drive with the transfer case. If the vehicle has two rear axles, both are usually in constant drive with the transfer case. The front driving axle is not in constant drive, however, because it can be disengaged or engaged either manually or automatically.

QUESTION 9.

? ?

? Because a transmission has only one output shaft, a vehicle not equipped with a transfer case could have ?

? a. only one driving axle. ?

? b. more than one driving axle. ?

? ?

Frame 10.

Answers to previous questions:

8. c.

9. a.

QUESTIONS 10 and 11.

? ?

? 10. What automatically engages and disengages the front wheel drive? ?

?
a. Front driving axle.
?
b. Sprag unit.
?
c. Transfer case.
?
d. Rear driving axle.
?

? 11. How does a Sprag unit operate? ?

? a. Outer race turns faster than inner, Sprags pivot, races lock together. ?

? b. Inner race turns faster, Sprags pivot, races lock together. ?

? ?

Answers to previous questions:

10. b.
11. a.

The principal means of delivering torque produced by the engine to the driving axles is by use of a propeller shaft. Some vehicles use drive chains while others use a direct drive from the transmission to the axle. However, most of the vehicles you will be working with, will use a propeller shaft to deliver the engine torque to the driving axles. Propeller shafts may be either solid or tubular, and are usually equipped with a universal joint on each end.

QUESTIONS 12 and 13.

? ?

? 12. Power is transferred from the transmission to the driving axles by the ?

? a. transfer case. ?

? b. Sprag assembly. ?

? c. propeller shaft. ?

? d. crankshaft. ?

? 13. What is the least number of propeller shafts a vehicle may have? ?

? a. 1. ?

? b. 2. ?

? c. 3. ?

? d. 4. ?

? ?

? ?

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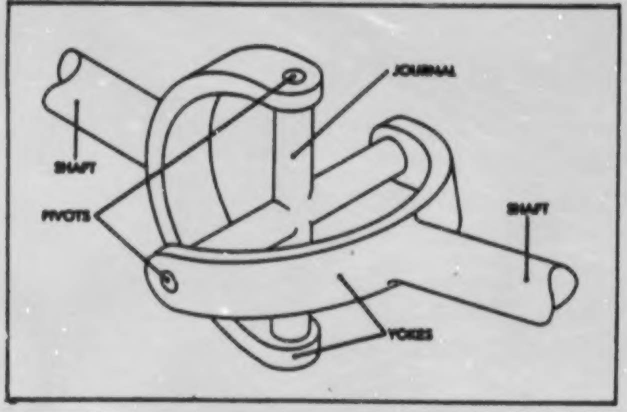
Frame 12.

Answers to previous questions:

12. c.

13. a.

In the last frame we said that a propeller shaft is usually equipped with a universal joint at each end, but some may have a "U" joint on only one end. Universal joints are used to transmit torque through varying angles. The figure below shows a real simple "U" joint which consists of three main parts: a journal and two yokes. No matter how complex a universal joint may be made, it will still contain these three main parts.



QUESTION 14.

? ?

? The three main parts of a universal joint are the ?

? a. shaft and two yokes. ?

b. journal and two shafts.

? c. journal and two yokes. ?

? d. yoke and two journals. ?

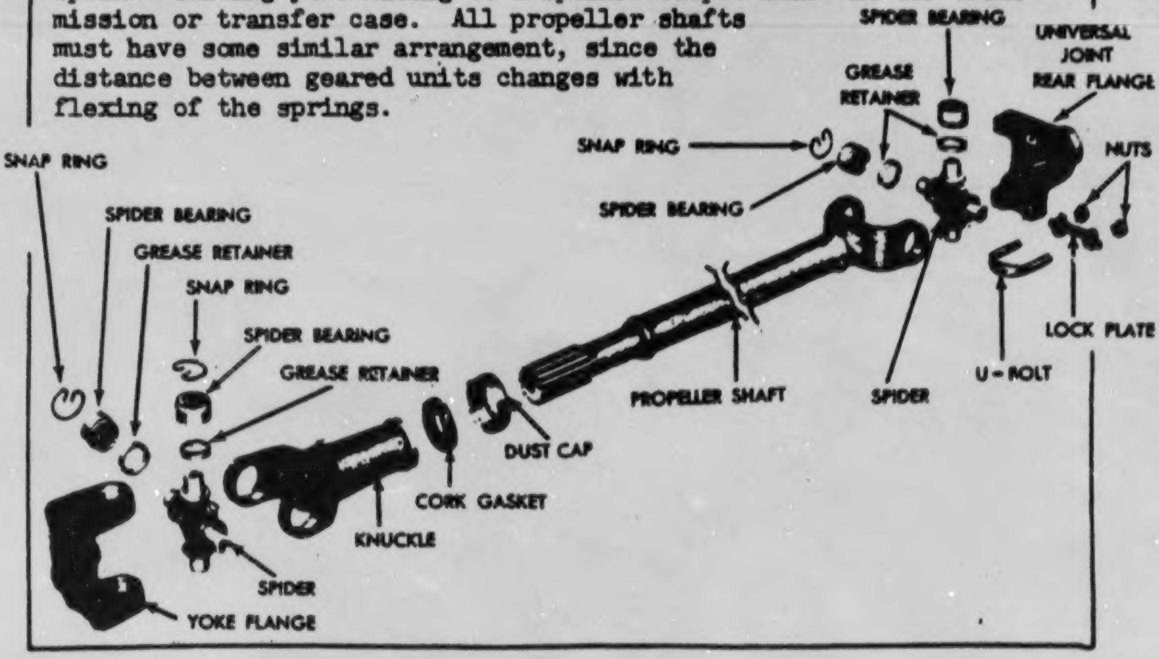
? ?

? ?

Frame 13.

Answer to previous question: 14. c.

The illustration below is an exploded view of a typical propeller shaft assembly. Essentially, it is a propeller shaft with a universal joint mounted on each end. One end of the shaft has a fixed yoke, the other end is splined so as to allow the universal joint to move. The yoke which mounts here is called the "splined sliding yoke." Some installations have fixed yokes on both ends of the shaft, with the splined sliding yoke mating to a splined output shaft in the transmission or transfer case. All propeller shafts must have some similar arrangement, since the distance between geared units changes with flexing of the springs.


SPIDER BEARING
UNIVERSAL JOINT REAR FLANGE
GREASE RETAINER
SNAP RING
NUTS
SPIDER BEARING
SNAP RING
SPIDER BEARING
GREASE RETAINER
SNAP RING
SPIDER BEARING
GREASE RETAINER
LOCK PLATE
PROPELLER SHAFT
SPIDER
U-BOLT
DUST CAP
CORK GASKET
KNUCKLE
SPIDER
YOKE FLANGE

QUESTION 15.

? ?

? Why is a slip joint used on one end of the propeller shaft? ?

? a. To allow the length of the propeller shaft to vary, due to spring flexing. ?

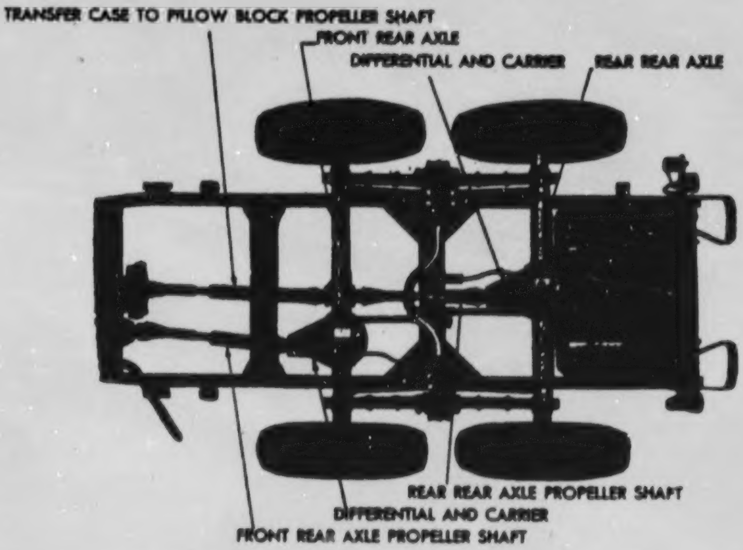
? b. To maintain constant torque through varying angles. ?

? ?

Frame 14.

Answer to previous question: 15. a.

Some vehicles are equipped with two rear driving axles which are suspended from a single trunnion axle. This arrangement gives great flexibility for going over rough terrain, and is commonly referred to as a "bogie unit." In this installation, power is transmitted to the rear rear axle through two propeller shafts connected in tandem (one behind the other) at a pillow block. The pillow block is mounted on the forward rear axle housing. The illustration below depicts the arrangement just described. Study the illustration carefully, then proceed to Question 16 below.


TRANSFER CASE TO PILLOW BLOCK PROPELLER SHAFT
FRONT REAR AXLE
DIFFERENTIAL AND CARRIER
REAR REAR AXLE
REAR REAR AXLE PROPELLER SHAFT
DIFFERENTIAL AND CARRIER
FRONT REAR AXLE PROPELLER SHAFT

QUESTION 16.

? ?

? What are the names of the two propeller shafts described in the text and illustration above? ?

?

____, AND

?

____.

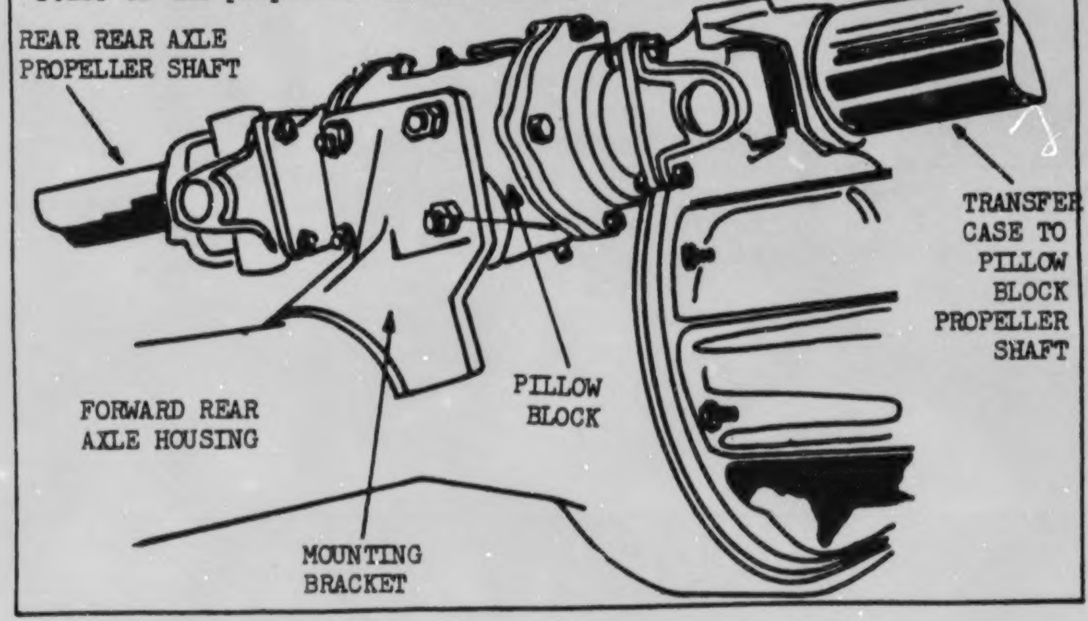
?

? ?

Answers to previous questions:

16. "Transfer case to pillow block propeller shaft," AND "rear rear axle propeller shaft."

The pillow block is mounted to a bracket which is welded to the forward rear axle housing. It consists of a shaft which is supported at both ends by ball bearings. Each end of the shaft mounts a flange for connecting the flange yoke of the propeller shaft universal joints. The illustration below shows the pillow block installed with only stubs of the propeller shafts showing.


REAR REAR AXLE PROPELLER SHAFT
TRANSFER CASE TO PILLOW BLOCK PROPELLER SHAFT
PILLOW BLOCK
FORWARD REAR AXLE HOUSING
MOUNTING BRACKET

QUESTION 17.

? ?

What is the purpose of the pillow block?

a. To transmit torque to one rear axle when the other loses traction.

b. To provide a means of distributing torque to more than one axle.

c. To permit flexibility of the driving axles while still providing torque to the second axle.

? ?

Frame 16.

Answer to previous question:

17. c. Responses "a" and "b" are partially correct, but they are not the true purpose of the pillow block.

On some vehicles the distance between the output shaft and the transmission or transfer case and the rear driving axle is so great that one long propeller shaft would tend to "whip" or vibrate. Also, such a shaft would contact the ground when passing over sharp rises such as curbings, driveways, etc. To prevent these occurrences, two short propeller shafts with a center bearing between them, are used. A center bearing is similar to a pillow block in configuration, but the center bearing is installed in a bracket which is bolted or welded to a frame cross-member. Ambulances, airport limousines, and other long wheelbase vehicles, as well as trucks, use a center bearing.

QUESTION 18.

? ?

What is the purpose of the center bearing?

a. Supports the center portion of the drive line when two propeller shafts are used in tandem.

b. Eliminates whipping and vibration that would occur if only one long propeller shaft was installed.

c. Prevents the shaft from contacting the ground when the vehicles pass over sharp rises.

d. All of the above are correct.

? ?

Answer to previous question:

18. d. The center bearing (sometimes called a "carrier bearing" does all those things.

All of the equipment discussed so far in this lesson is involved in transmitting power to the wheels. While this enables the vehicle to operate on most types of terrain, certain weather conditions may render the vehicle immobile regardless of the number of wheels it may have turning. This is where the winch comes into its own. By securing the winch cable to a solid object ahead of the vehicle, such as a tree, post, another vehicle, etc., the vehicle can pull itself through almost anything. The winch may also be used to pull other vehicles or pieces of equipment.

QUESTION 19.

? ?

? What is the purpose of the winch on a vehicle? ?

? a. To enable the vehicle to pull itself out of any immobilizing situation, as long as the engine is still operating. ?

? b. To provide a means of extracting other vehicles or equipment. ?

? c. Both "a" and "b" above. ?

? d. Neither "a" nor "b". ?

? ?

Frame 18.

Answer to previous question:

19. c.

The winches installed on most vehicles are mounted behind the front bumper of the vehicle. The winch is driven by a solid propeller shaft from a power take-off. This power take-off (PTO) may be mounted on either the transfer case or the transmission, and it is controlled by a lever in the vehicle's cab.

QUESTION 20.

? ?

? How is the winch powered? ?

? a. By a lever in the driver's cab. ?

? b. By a propeller shaft from the power take-off. ?

? c. Both "a" and "b" above. ?

? d. Neither "a" nor "b". ?

? ?

Frame 19.

Answer to previous question:

20. b. If you selected response "c", consider that the question asked only how the winch was powered, not how it was controlled.

The propeller shaft from the PTO to the winch has a universal joint at each end. The front universal joint incorporates a shear pin which prevents damage to the driving mechanism in the event that the winch is overloaded. There is a safety brake on the drum of the winch to hold the load in any desired position or to hold the load if the shear pin breaks.

QUESTION 21.

? ?

? What is the purpose of the safety brake on the drum of the winch? ?

? a. It prevents damage to the driving mechnism in the event the winch is overloaded. ?

? ?

? b. It holds the load in the desired position, or in the event that the shear pin breaks. ?

? c. Both "a" and "b" above. ?

? d. Neither "a" nor "b". ?

? ?

Frame 20.

Answer to previous question:

21. b.

This portion of the lesson, covering the first two objectives, is now completed. You should be able to:

1. Select the correct answers for multiple-choice questions which describe the purpose and operating principles of:
   a. Universal joints.
   b. Propeller shafts.
   c. Center bearings.
   d. Pillow blocks.
   e. Transfer cases.
   f. Sprag units.
   g. Winches.
2. Identify and locate the above listed units on an illustration.

The remaining portions of this lesson will be accomplished in the Laboratory, since it is all performance on actual vehicle components. Before going to the laboratory, however, check with your instructor for he may want to administer a test on this Programmed Instruction Package.

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PREPARE THE MAN PROGRAMMED TEXT 3ABR47~~330~~232-PT-504

Technical Training

8-11

General Purpose Vehicle ~~Repairmen~~ Mechanic

FRONT AND REAR DRIVING AXLES

12 May 1971

CHANUTE TECHNICAL TRAINING CENTER (ATC)

This supersedes PT 3ABR47330-PT-504, 4 March 1970.
OPR: TDWS
DISTRIBUTION: X
TDWS - 50; TTOC - 2

Designed For ATC Course Use

OBJECTIVES

Upon completion of this text, you will be able to accomplish the following objectives with 85% accuracy.

1. Given a list of drive train functions, pick out those which apply to the driving axle assembly only.

2. Name the four major components of the driving axle assembly.

3. State two possible functions of the axle housing.

4. Name the unit which gives a fixed gear reduction in a driving axle assembly.

5. Name the two gears of a final drive.

6. Given the number of teeth on a ring gear and the number of teeth on a pinion gear, compute the gear ratio.

7. State the most commonly used final drive.

8. State the advantage of using a double reduction driving axle.

9. Given a list of troubles, pick out the two most often occurring in a final drive.

10. State the purpose of a conventional differential.

11. Name the three major parts of a differential assembly.

12. State the difference between a full-floating and semifloating drive axle.

13. Name the mechanism which makes it possible for front driving axles to steer while driving the wheels.

INSTRUCTIONS

In this programmed text you will be given information in small sections called frames. After most frames you will be asked a question or given a problem to solve, using the information acquired in the frame you just read or previous frames.

The correct answer for the question will be at the top of the top of the page following the question, for maximum learning. Solve the problem and check it over before looking at the "school solution." If you selected the correct answer, procede with the text. If you selected the wrong answer, go back over your work until you find where you were wrong before proceeding to the next frame.

If you cannot determine where or why you made a mistake, ask your instructor to explain it to you.

So far in the course you have learned that a vehicle's power is generated by the engine, and transferred through the transmission and/or transfer case, and then along a propeller shaft to the front or rear axle assembly. This axle assembly is where we will begin this lesson.

Driving axle assemblies have several functions. They are:

1. Holding the wheels on.
2. Keeping the wheels upright.
3. Driving the wheels.
4. Giving a fixed gear reduction.
5. Changing the direction of power 90°.
6. Letting one wheel turn faster than the other while both are receiving torque.
7. Sometimes supporting the vehicle's weight.

Question 1.

Draw a line through the statement which in not a function of driving axle assemblies.

A. Giving a fixed gear reduction.

B. Changing the direction of power 180°.

C. Holding the wheels on and upright.

D. Letting one wheel turn faster than the other while both are receiving torque.

Answer to question 1.

If you drew a line through the statement of letter B, you were correct.

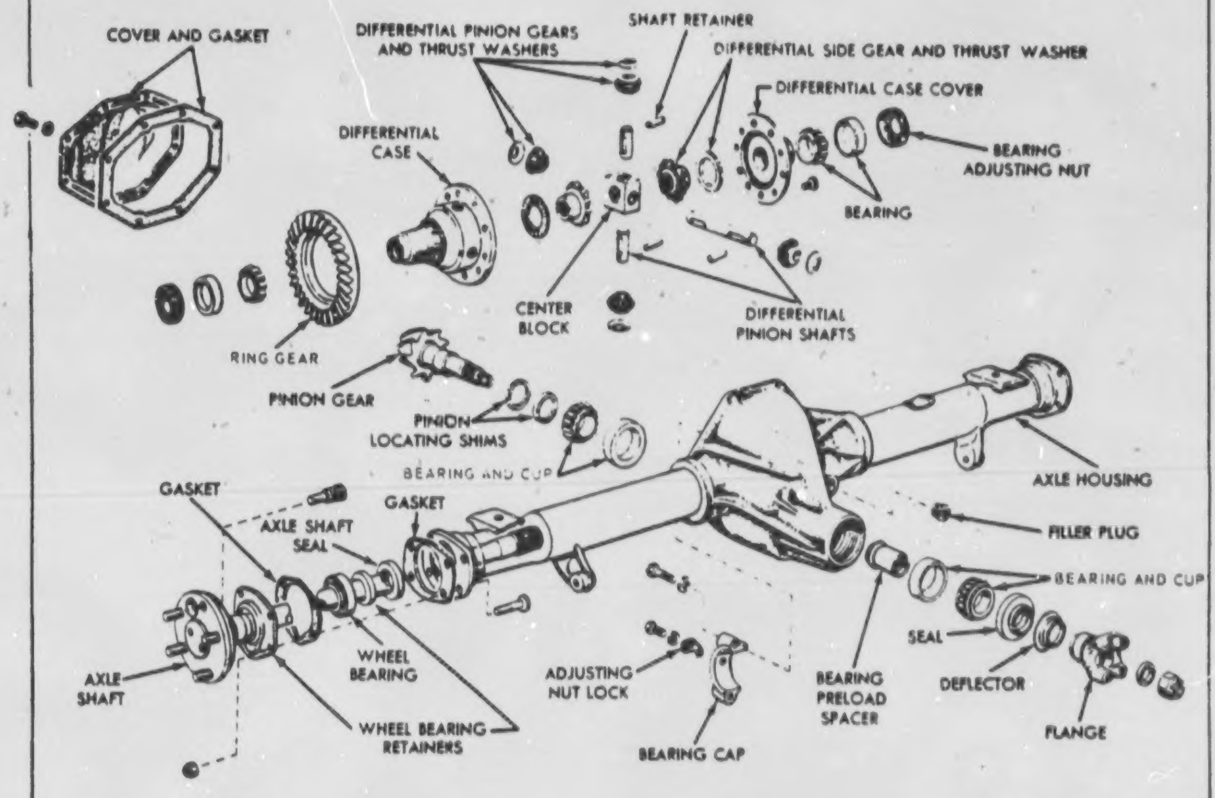
Driving axle assemblies consist of four major components.

1. The axle housing.
2. The final drive.
3. The differential.
4. The axle shafts.

We shall discuss each of these in turn.

Illustration Panel

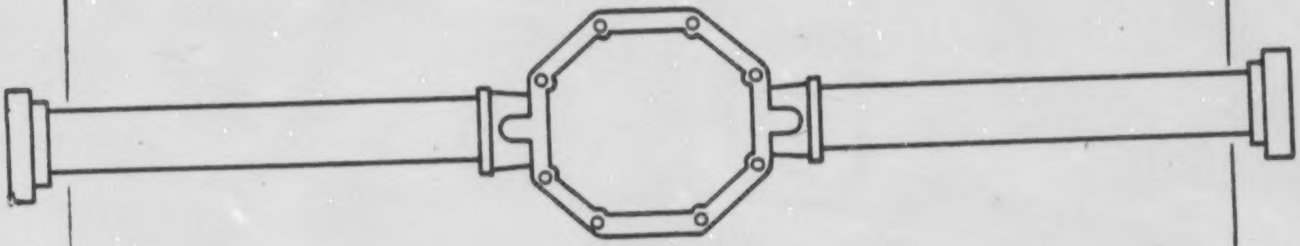
Refer back to this panel to relate each of the major components to the complete driving axle assembly.


COVER AND GASKET
DIFFERENTIAL PINION GEARS AND THRUST WASHERS
SHAFT RETAINER
DIFFERENTIAL SIDE GEAR AND THRUST WASHER
DIFFERENTIAL CASE COVER
DIFFERENTIAL CASE
BEARING ADJUSTING NUT
BEARING
CENTER BLOCK
DIFFERENTIAL PINION SHAFTS
RING GEAR
PINION GEAR
PINION LOCATING SHIMS
BEARING AND CUP
AXLE HOUSING
GASKET
AXLE SHAFT SEAL
GASKET
FILLER PLUG
BEARING AND CUP
SEAL
DEFLECTOR
WHEEL BEARING
AXLE SHAFT
ADJUSTING NUT LOCK
BEARING PRELOAD SPACER
FLANGE
WHEEL BEARING RETAINERS
BEARING CAP

Axle Housing

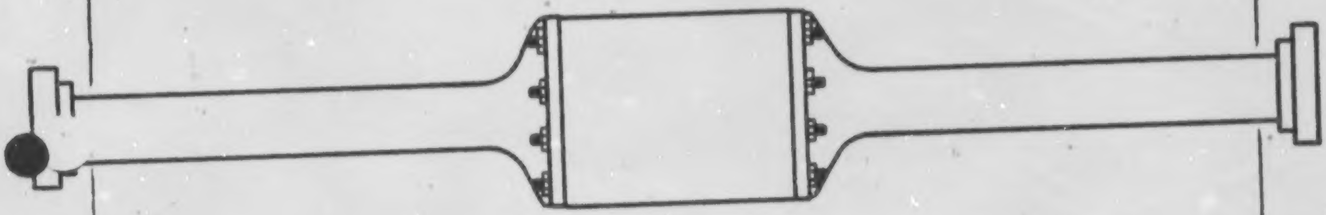
The axle housing is usually made of stamped steel parts welded together, or the center section may be made of cast steel. Two basic types of housings have been used.

The Banjo type (in wide use) is so called because of its resemblance to the musical instrument.



Banjo Type Axle Housing

The split type (little used) is so called because it consists of 3 pieces bolted together which may be unbolted and "split" apart.



Split Type Axle Housing

Question 2.

Fill in the blank space with the correct one-word answer.

The axle housing which is most widely used in vehicles today is called the

____________________ type.

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Answer to question 2. Banjo

The purpose of the axle housing is to house the axle shafts and diferential components and provide a lubrication bath for them. Sometimes they are called on to support some of the vehicle's weight.

Question 3.

True or False

The axle housing supports the vehicle's weight and drives the wheels.

The only maintenance that is normally required for axle housings is to periodically inspect its fluid level and to insure that its vent is not stopped up.

Question 4.

What could happen to an axle housing as the result of a stopped up vent?

Select the best answer.

A. The lubricant would not receive proper cooling.

B. The housing seals would start to leak.

C. The wheels would become hard to turn.

D. Axles would not receive proper lubrication.

Answer to question 3. False

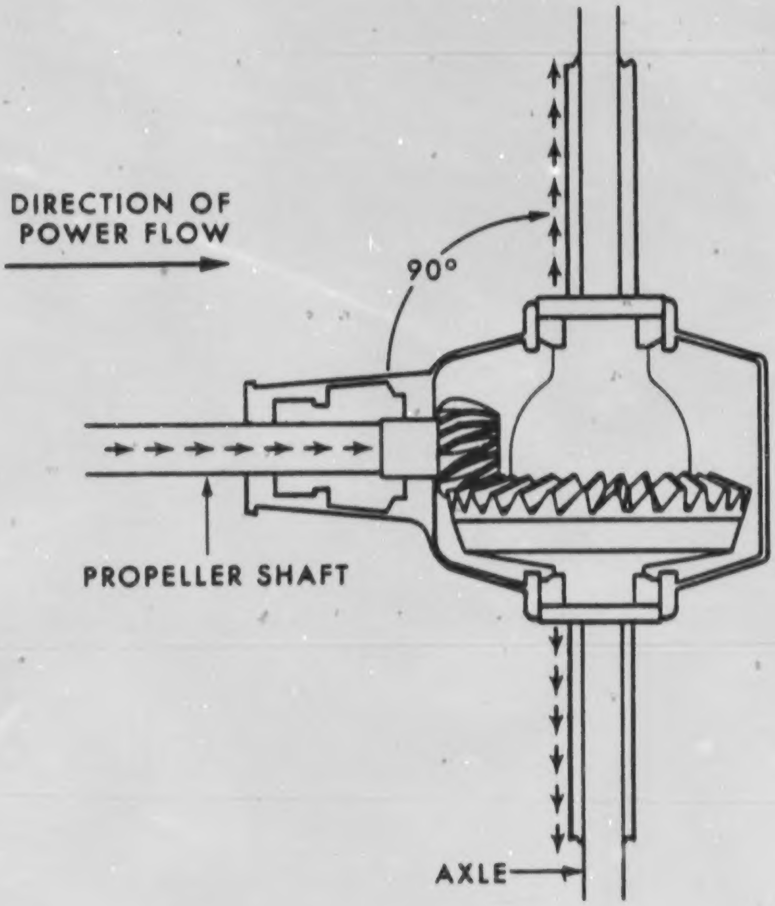
Answer to question 4. B - Pressure from normal heat expansion of lubricant and gases in the housing would seap past the housing seals if there was no venting action. You should have remembered this from previous lessons.

Final Drive

The final drive serves two purposes.

1. It provides a mechanical advantage (fixed gear reduction) from the propeller shaft to the rear axle.

2. It turns the power flow at right angles from the propeller shaft to the axle shaft.



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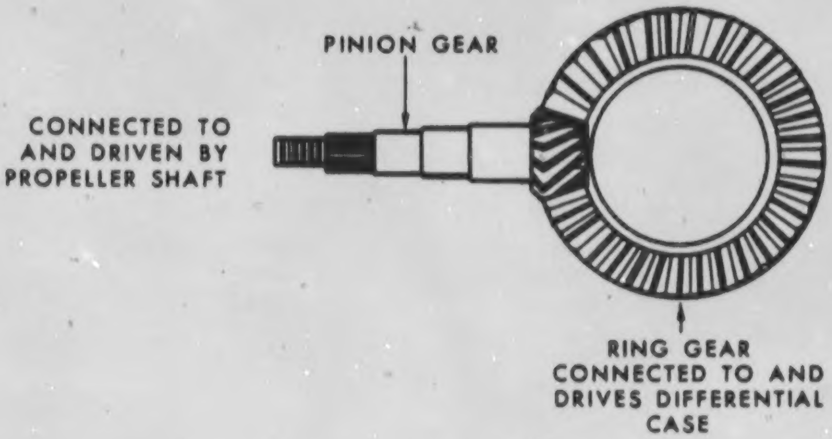
In passenger cars the final drive consists of a pair of spiral bevel gears called the ring and pinion gears.


PINION GEAR
CONNECTED TO AND DRIVEN BY PROPELLER SHAFT
RING GEAR CONNECTED TO AND DRIVES DIFFERENTIAL CASE

Question 5.

True or False

The connection provided by the ring and pinion gears changes the direction of the power through 90° to the driving axles from the propeller shaft.

The gear reduction in a single reduction driving axle is obtained by making the ring gear larger and having more teeth than the pinion gear. In order to obtain a reduction of 3 to 1, the ring gear must have 3 times as many teeth as the pinion. For example, if the pinion gear had 10 teeth, the ring gear would need 30 teeth for a 3:1 ratio.

Question 6.

If a pinion gear has 12 teeth, how many teeth must the ring gear have for a 4:1 ratio?

A. 54 teeth.

B. 36 teeth.

C. 48 teeth.

D. 42 teeth.

Answer to question 5.	True
Answer to question 6.	C

A popular rule for determining a gear ratio is to divide the number of teeth on the driven gear by the number of teeth on the drive gear. In the case of the final drive unit, the pinion gear is the drive and the ring gear is the driven gear.

$$\text{Gear ratio} = \frac{\text{Number teeth driven gear (ring)}}{\text{Number teeth drive gear (pinion)}}$$

Example: Ring gear $\frac{48}{13}$ teeth.
Pinion gear 13 teeth.

```
     3.692      =   Rounded off to the nearest hundredths   =   3.69
 13/48.00
    39
     90             Therefore, the gear ratio is 3.69:1 meaning that
     78             the pinion gear must turn 3.69 times in order to
     120            drive the ring gear around once.
     117
       30
```

Question 7.

Given a ring gear with 47 teeth and a pinion gear with 12 teeth, what is the gear ratio to the nearest hundredth?

A. 4.11:1

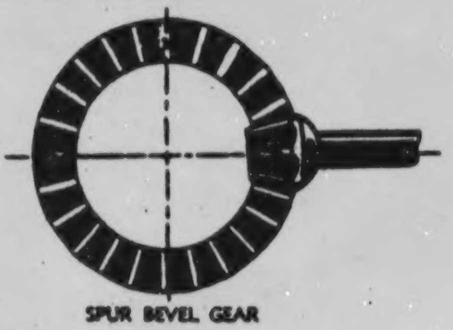
B. 3.90:2

C. 2.83:1

D. 3.92:1

Answer to question 7. D

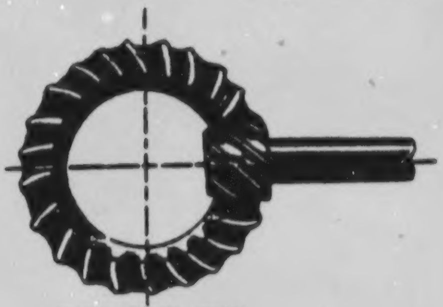
Three major types of final drives have been used over the years. One of the very earliest was the Spur Bevel.



SPUR BEVEL GEAR

Its major advantage was that it was simple to manufacture. Its disadvantages were that it was noisy and not overly strong.

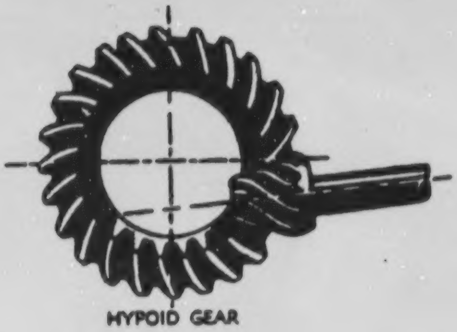
Later engineers changed the shape of the gears and made them Spiral Bevel



SPIRAL BEVEL GEAR

This type of gear was quieter and stronger. It was used until 1948.

After 1948 engineers introduced the hypoid type final drive.



HYPOID GEAR

It was quiet, smooth, and strong. Also by observing the illustration, you can see that the mashing point of the ring and pinion gear is below the centerline of the ring gear. This allows the whole driveline to be lowered and the vehicle may set lower to the ground without an unusually large tunnel or "hump" in the floorboard to accommodate the propeller shaft. Also the pinion could now be setting in lubricant al all times in the hypoid type drive, while the spur bevel and spiral bevel were lubricated by the splash system. The hypoid type final drive is the one most vehicles use today.

Question 8.

Why is the hypoid type final drive used today?

A. It is strong.

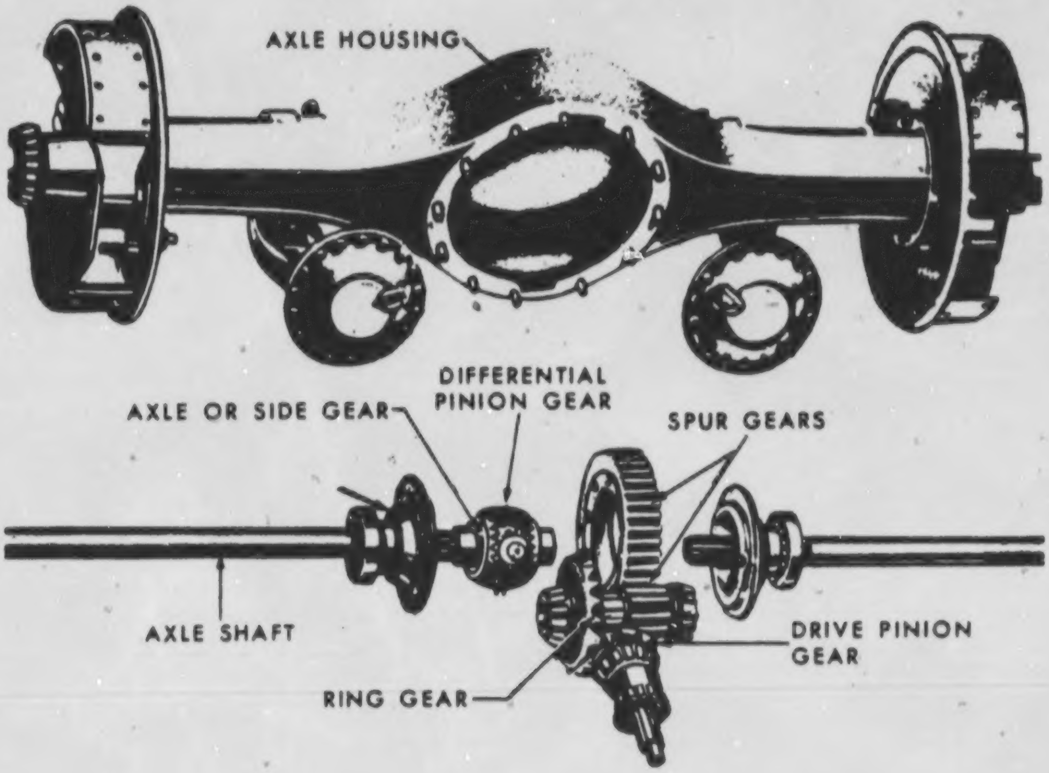
B. It is quiet.

C. It is better lubricated.

D. All of the above.

Answer to question 8. D

A double reduction driving axle has a spur pinion gear and a spur drive gear in addition to the basic gear system used in a single reduction driving axle. In the double reduction driving axle, the spur drive gear is the largest gear and the differential gear assembly is mounted on or inside the spur drive gear instead of the ring gear. The relationship of the other components is basically the same in both the single and double reduction driving axles.


AXLE HOUSING
DIFFERENTIAL PINION GEAR
AXLE OR SIDE GEAR
SPUR GEARS
AXLE SHAFT
DRIVE PINION GEAR
RING GEAR

The gear reduction in a single reduction driving axle is obtained by making the ring gear larger than the pinion gear and having more gear teeth than the pinion gear. In order to obtain a reduction of 6 to 1, the ring gear must be six times as large as the pinion gear. If the pinion gear were four inches in diameter, the ring gear would have to be twenty-four inches in diameter. A differential housing under a vehicle that was more than twenty-four inches in diameter would cause a good deal of trouble, so a double reduction driving axle would be better. To obtain the same gear reduction the pinion gear could be the same four inches in diameter, the ring gear could be eight inches in diameter, the pinion spur gear could be three inches in diameter and the spur drive gear could be nine inches in diameter. This arrangement would give a gear ratio of 6 to 1 and the largest gear only nineee inches in diameter.

Question 9.

What is the advantage of using a double reduction driving axle?

A. It provides six times the amount of gear reduction.

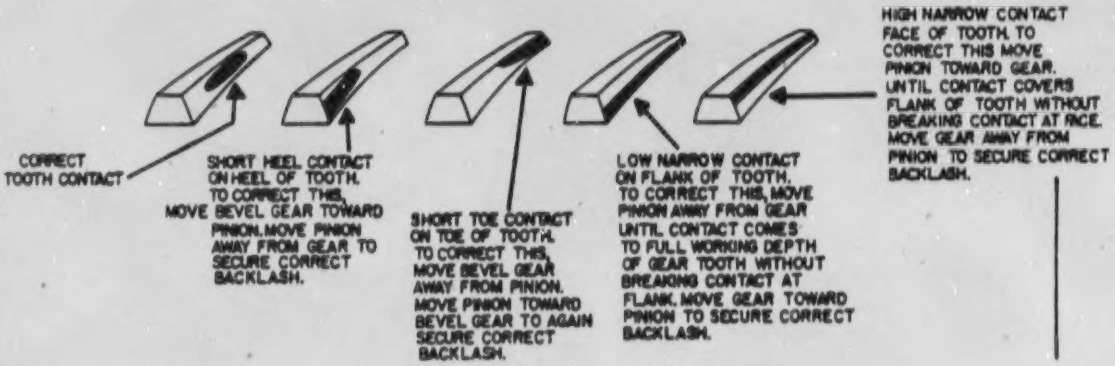
B. It eliminates the need for a ring gear.

C. It provides a large gear reduction with smaller diameter gears.

D. It places the stresses caused by turning, skidding, wheel wobble, and the weight of the vehicle on the axle housing.

Answer to question 9. C

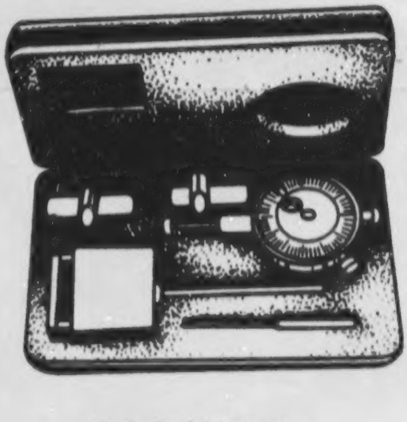
Two troubles in rear axle gear assemblies are gear runout and backlash. Gear runout is either a crooked gear or a gear not mounted straight on the shaft or in the housing. Backlash is caused by a gear moving back from its proper position because of wear. Both of these troubles can be checked for by lightly coating the surfaces of the gear teeth of one gear with red lead or prussian blue, turning the gear, and observing the types of gear tooth contact that may be observed. The "heel" of a gear is toward the outer edge of the gear and the "toe" of a gear tooth is toward the center of the gear.


CORRECT TOOTH CONTACT
SHORT HEEL CONTACT ON HEEL OF TOOTH. TO CORRECT THIS, MOVE BEVEL GEAR TOWARD PINION. MOVE PINION AWAY FROM GEAR TO SECURE CORRECT BACKLASH.
SHORT TOE CONTACT ON TOE OF TOOTH. TO CORRECT THIS, MOVE BEVEL GEAR AWAY FROM PINION. MOVE PINION TOWARD BEVEL GEAR TO AGAIN SECURE CORRECT BACKLASH.
LOW NARROW CONTACT ON FLANK OF TOOTH. TO CORRECT THIS, MOVE PINION AWAY FROM GEAR UNTIL CONTACT COMES TO FULL WORKING DEPTH OF GEAR TOOTH WITHOUT BREAKING CONTACT AT FLANK. MOVE GEAR TOWARD PINION TO SECURE CORRECT BACKLASH.
HIGH NARROW CONTACT FACE OF TOOTH. TO CORRECT THIS MOVE PINION TOWARD GEAR. UNTIL CONTACT COVERS FLANK OF TOOTH WITHOUT BREAKING CONTACT AT FACE. MOVE GEAR AWAY FROM PINION TO SECURE CORRECT BACKLASH.

Gear runout (crooked gear) will show up as low narrow contact on one part of the gear and high narrow contact on the opposite part. Excessive backlash of the pinion gear will show up as short heel contact if it has backed away from the ring gear and short toe contact if it is in too far toward the ring gear. Excessive backlash of the ring gear will show up as low narrow contact if it is too close to the pinion gear and high narrow contact if it is too far away from the pinion gear.

Another way gear runout and backlash may be checked is by using a dial indicator.

Your instructor will demonstrate to you how this is done, and will give you a chance to perform this check yourself.



Dial Indicator

Question 10.

What is the purpose of a gear tooth contact check?

A. To determine if the proper gears are installed.

B. To detect gear runout or backlash.

C. To determine if the rear axle is noisy.

D. To determine if a single or double reduction axle is being used.

Question 11.

When a gear is too close to or too far away from the gear it should mesh with, what is the trouble?

A. Gear runout.

B. Gear tooth contact.

C. Ring gear meshing with pinion gear.

D. Gear backlash.

Question 12.

What can be done to detect gear runout or backlash?

A. Drive the vehicle and measure the type of vibration.

B. Perform a gear tooth contact check.

C. Drive the vehicle and measure the amount of noise.

D. Drive the vehicle wheels on a lift and observe the operation of the rear axle from underneath.

Answer to question 10. B

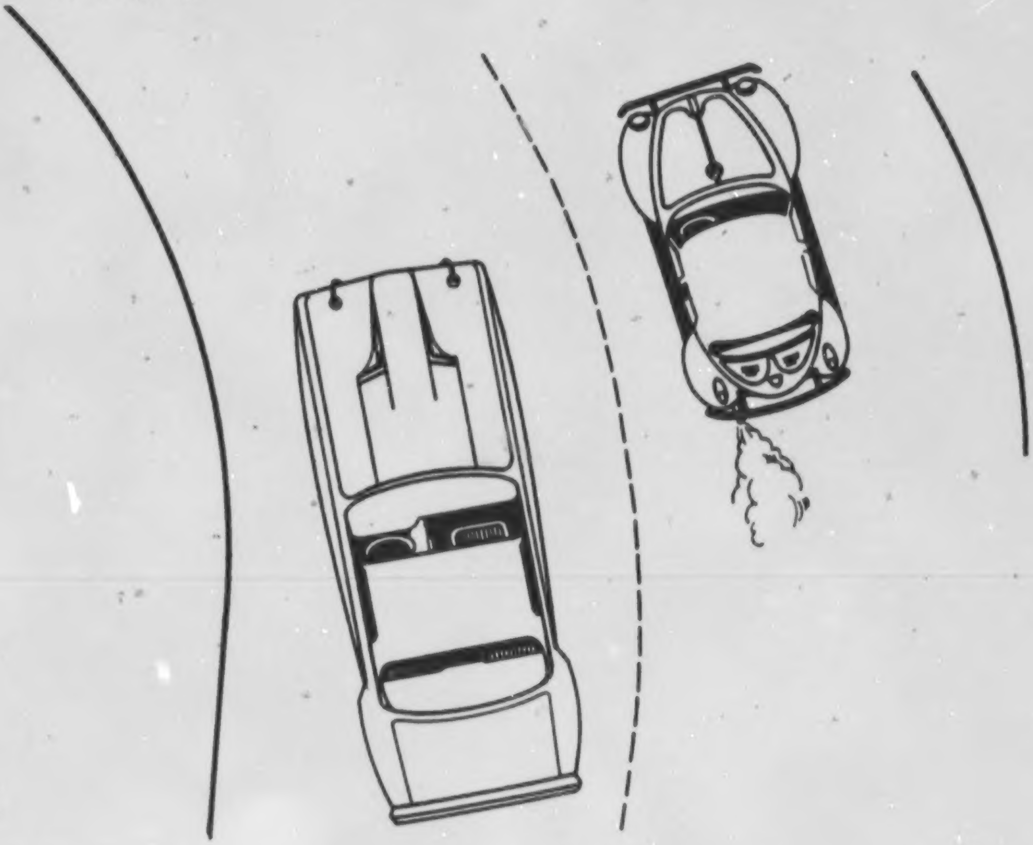
Answer to question 11. D

Answer to question 12. B

Conventional Differentials

If all the roads that vehicles had to travel were straight, we would not need a differential, but sooner or later all vehicles must turn a corner or curve. When this happens, the wheel on the outside of the curve must travel farther than the wheel on the inside of the curve.

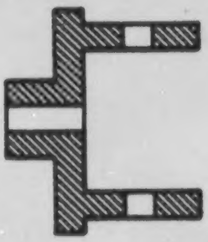
An example of this is two vehicles rounding a curve together. The vehicle on the outside must travel faster than the one on the inside in order to keep up.



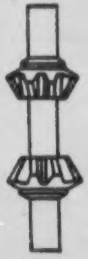
The purpose of the differential therefore is to allow one wheel to turn faster than the other, and at the same time, still transfer power from the propeller shaft to the axles.

The majority of differentials are composed of the following major parts.

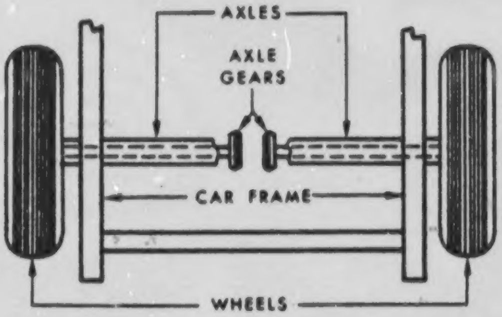
1. A differential carrier or case.



2. Two differential spider gears mounted on a differential pinion shaft.



3. Two side or axle gears.



Question 13.

What are the major parts of the differential?

A. Differential carrier, differential sidegears, pinion case.

B. Differential, pinion gear, ring gear, axle shafts.

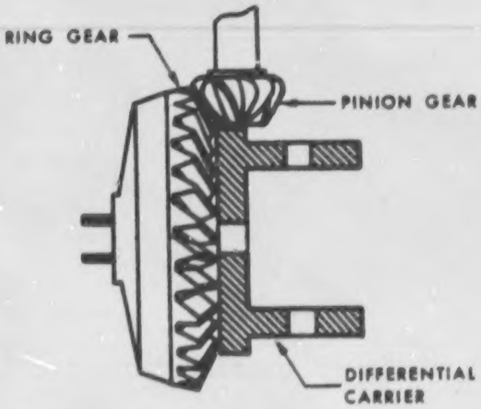
C. Pinion case, axle gears, wheels

D. Differential carrier, differential spider gears, axle gears.

422

Answer to question 13. D

The differential carrier is connected to and driven by the ring gear.

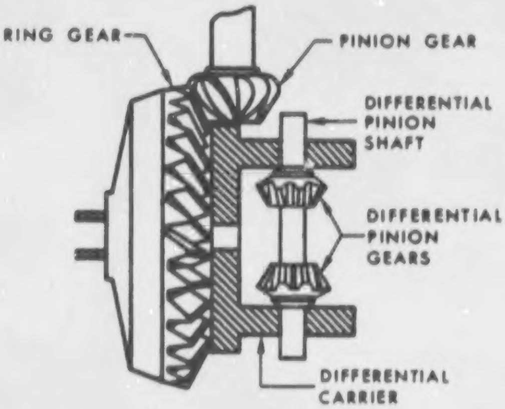

RING GEAR
PINION GEAR
DIFFERENTIAL CARRIER

Question 14.

Do you still remember what drives the ring gear? Write in your answer here.

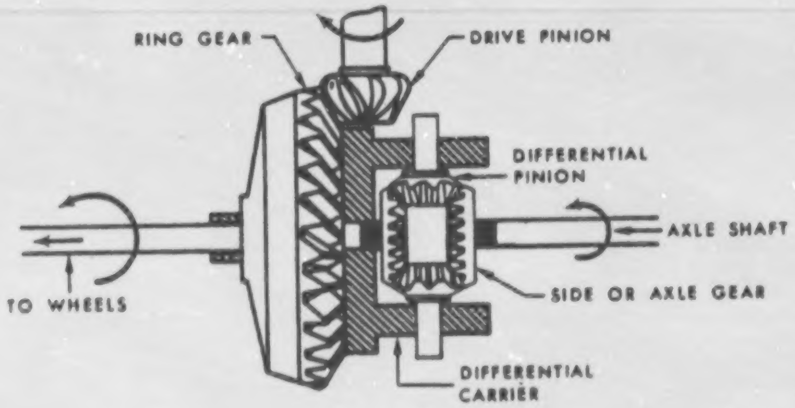
____________ ____________ ____________

The differential carrier drives the differential pinion shaft. The differential pinion shaft drives the differential pinion gears. These pinion gears are free to rotate on the shaft.


RING GEAR
PINION GEAR
DIFFERENTIAL PINION SHAFT
DIFFERENTIAL PINION GEARS
DIFFERENTIAL CARRIER

Answer to question 14. The pinion gear.

The two pinion gears are in mesh with and drive the two side or axle gears. The axle gears are splined to and drive the axle shafts, and therefore the wheels.


RING GEAR
DRIVE PINION
DIFFERENTIAL PINION
AXLE SHAFT
TO WHEELS
SIDE OR AXLE GEAR
DIFFERENTIAL CARRIER

When the vehicle rounds a curve, the differential pinion gears rotate on their shaft transmitting more rotary motion to one wheel than the other. When both wheels turn at the same speed, the differential pinion gears do not rotate on their shaft.

Question 15.

What unit in a driving axle provides for the differences in speed of the wheels?

A. Differential gear assembly.

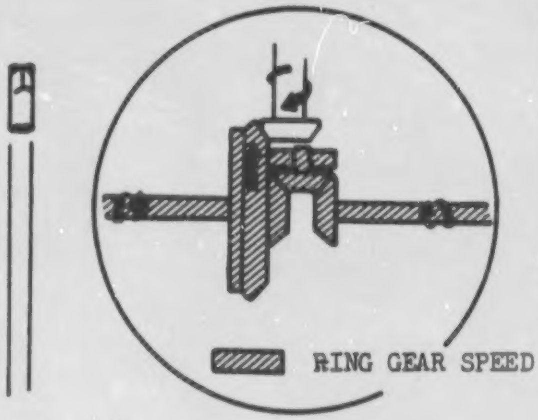
B. Ring gear.

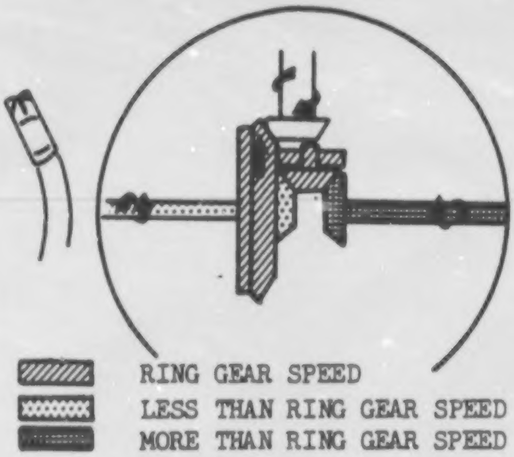
C. Pinion gear.

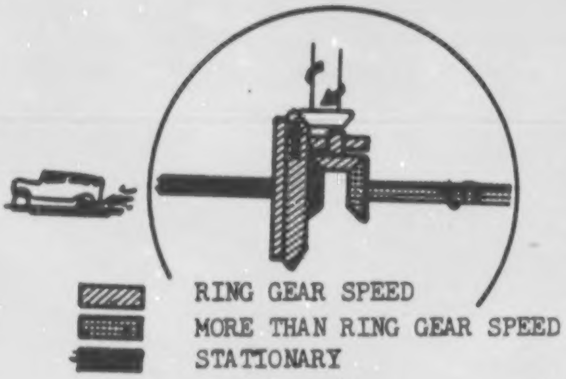
D. Ring and pinion gear assembly.

Answer to question 15. A

Observe in the illustration to the right that in normal straight ahead driving, the axles rotate at the same speed as the ring gear. The left illustration below shows the left axle turning slower and the right axle turning faster than the ring gear in a left turn. The right illustration below shows the left axle stopped and the right axle turning twice the speed of the ring gear as in mud or ice.


▨ RING GEAR SPEED


▨ RING GEAR SPEED
▒ LESS THAN RING GEAR SPEED
■ MORE THAN RING GEAR SPEED


▨ RING GEAR SPEED
▒ MORE THAN RING GEAR SPEED
■ STATIONARY

Axle Shafts

The axle shafts are the parts of the drive axle assembly which transmit torque from the differential gears to the wheels. In some cases they also help support the weight of the vehicle.

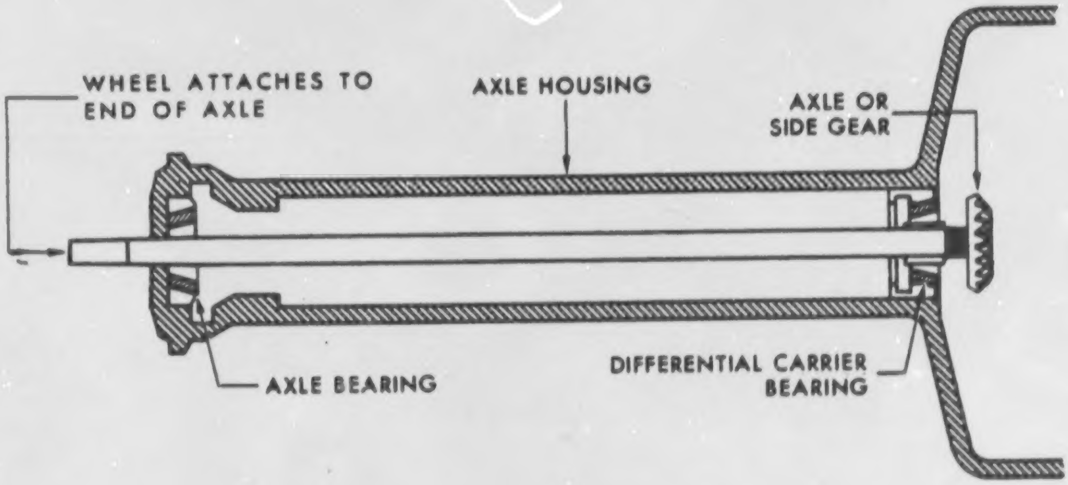
Question 16.

True or False

The axle shaft transmits torque from the differential gears to the wheels.

There are two main types of drive axles used on general purpose vehicles. They are the semifloating axle and the full-floating axle. The difference between the two has to do with the duties imposed on the axle shaft.

The semifloating axle is used mainly on passenger cars and light trucks.


WHEEL ATTACHES TO END OF AXLE
AXLE HOUSING
AXLE OR SIDE GEAR
AXLE BEARING
DIFFERENTIAL CARRIER BEARING

In the semifloating axle, the axle shaft itself supports much of the vehicle weight (the wheels are attached to the ends of the axle) as well as propelling the vehicle. The axle bearings in a semifloating axle are located between the axle shaft and the inside of the axle housing.

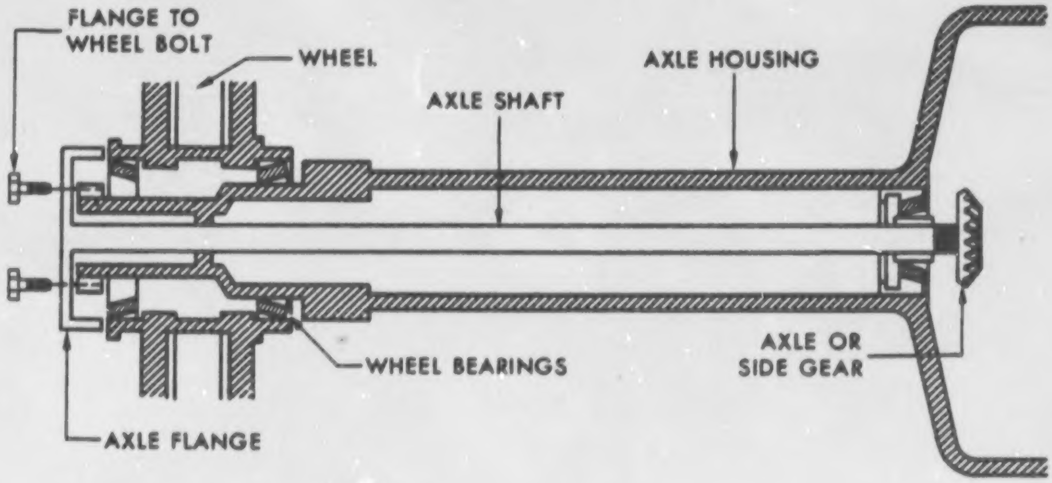
Answer to question 16. True

Question 17.

Fill in the blank spaces with the correct answers.

Most of the weight of a vehicle equipped with a semifloating axle is supported by the ________________ ________________.

The full-floating axle is used mainly on trucks, 3/4 ton and heavier.


FLANGE TO WHEEL BOLT
WHEEL
AXLE HOUSING
AXLE SHAFT
WHEEL BEARINGS
AXLE OR SIDE GEAR
AXLE FLANGE

In the full-floating type drive axle, the axle itself does not carry any of the vehicle's weight. Its only purpose is to propel the vehicle.

The weight of the vehicle is supported by the axle housing (on which the wheel turns).

The axle bearings in a full-floating drive axle are located between the wheel and the outside of the axle housing.

Because the full-floating type drive axle does not carry any of the vehicle weight, it may be removed without jacking up the vehicle.

Answer to question 17.	axle shafts

Question 18.

What type rear driving axle has all of the weight of the vehicle and the stresses caused by turning, skidding, and wheel wobble on the axle shaft?

A. Plain.

B. Semifloating.

C. Full floating.

D. Three-quarter floating.

Question 19.

What type rear driving axle has all of the weight of the vehicle and the stresses caused by turning, skidding, and wheel wobble on the axle housing?

A. Three-quarter floating.

B. Full-floating.

C. Semifloating.

D. Plain.

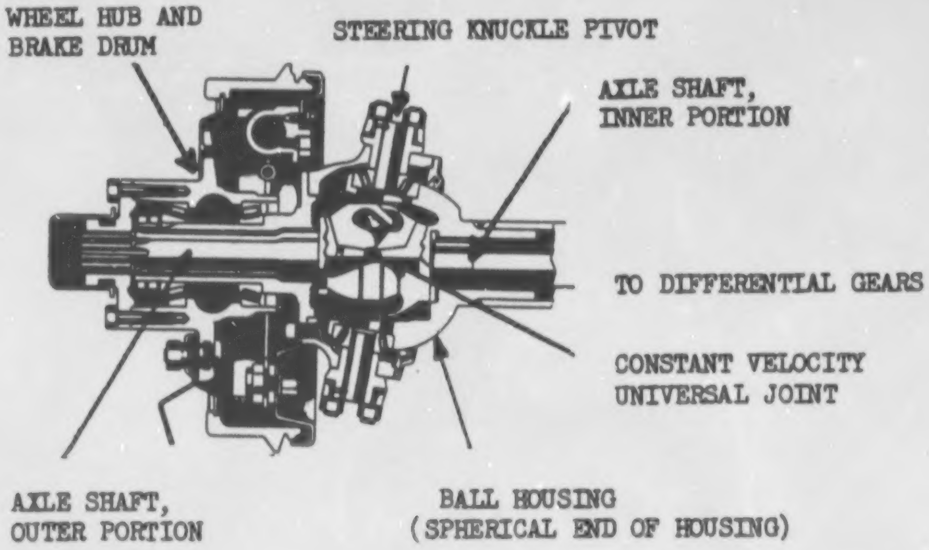
Answer to question 18. B

Answer to question 19. B

Front Driving Axles

Some heavy duty vehicles have driving axles in the front as well as the rear. The primary difference between front and rear driving axles is that front driving axles must have a means of steering. This is accomplished through steering linkage and steering knuckle pivots in the axle housing. Since the axle must be capable of propelling the vehicle while the wheels are turned, it must have a universal joint at each steering knuckle pivot. Standard U-joints like those used on a propeller shaft cause jerking, hard steering, slippage, and tire wear on turns; therefore, it is desirable to use a constant velocity U-joint in front driving axles. Some vehicles use standard U-joints in front driving axles despite their disadvantages.

The illustration below shows the principal parts of the outer section of a front driving axle. Using this illustration and your knowledge of rear driving axles, determine the differences between front and rear driving axles.


WHEEL HUB AND BRAKE DRUM
STEERING KNUCKLE PIVOT
AXLE SHAFT, INNER PORTION
TO DIFFERENTIAL GEARS
CONSTANT VELOCITY UNIVERSAL JOINT
AXLE SHAFT, OUTER PORTION
BALL HOUSING (SPHERICAL END OF HOUSING)

Question 20.

What is the primary difference between front driving axles and rear driving axles?

A. Rear driving axles have a larger ring gear.

B. Front driving axles use double reduction to give more torque.

C. Rear driving axles have gears that provide for the differences in speed of the wheels in turns.

D. Front driving axles have constant velocity universal joints to permit turning while providing power.

Question 21.

What provides the flexible connection in a front driving axle housing?

A. Steering knuckle pivot and ball housing.

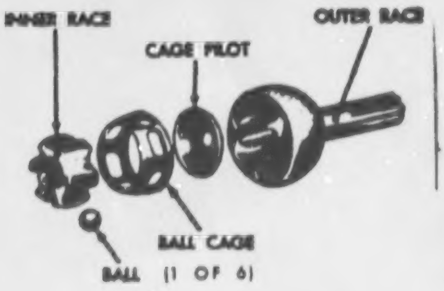
B. Constant velocity universal joint.

C. Ring and pinion gears.

D. Differential gears.

There are three types of constant velocity U-joints in common use. They are: Rzeppa, Tracta, and Bendix-Weiss.

The Rzeppa type U-joint has steel balls that provide a connection between the inner race and the outer race.

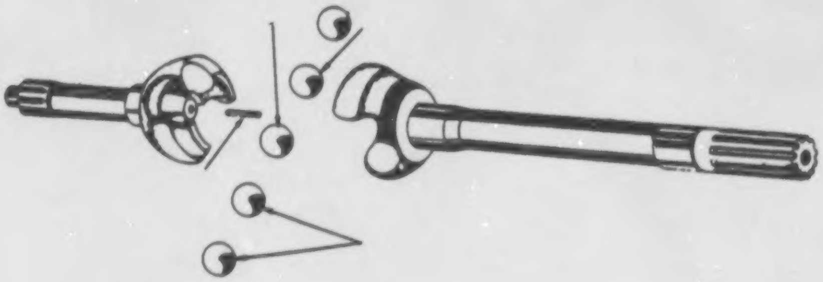


The Rzeppa U-joint has an inner race mounted on the end of the inner axle shaft and an outer race mounted on the end of the outer axle shaft. The steel balls are mounted in a cage and move as necessary to provide a flexible connection between the inner and outer races.

Answer to question 20. D

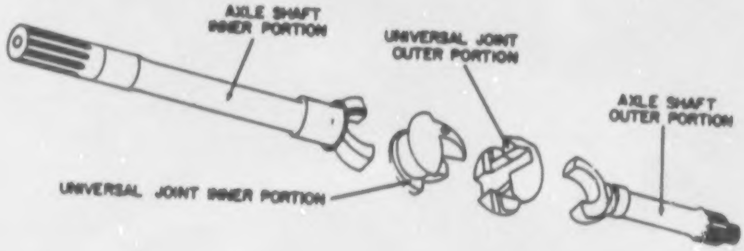
Answer to question 21. B

The Bendix-Weiss type U-joint has steel balls that provide a connection between two yokes.



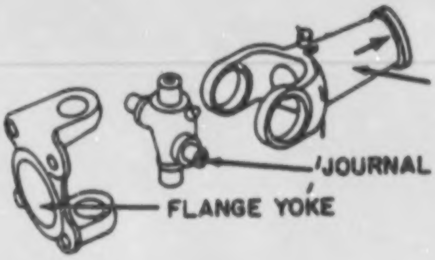
The Bendix-Weiss U-joint has a driving yoke on the end of the inner axle shaft and a driven yoke on the end of the outer axle shaft. The steel balls move as necessary to provide a flexible connection between the two yokes.

The Tracta type U-joint consists of four main parts: a forked driving shaft, a forked driven shaft, a female (outer) joint, and a male (inner) joint.


AXLE SHAFT INNER PORTION
UNIVERSAL JOINT OUTER PORTION
AXLE SHAFT OUTER PORTION
UNIVERSAL JOINT INNER PORTION

The Tracta U-joint has forks on the end of both the inner and outer axle shafts. The fork of the inner axle shafts fits into slots in the male (or spigot) joint and the fork of the outer axle shaft fits into slots in the female (or slotted) joint. The male and female joints move as necessary to provide a flexible connection between the forks of the inner and outer axle shafts.

The Carden type U-joint is not a constant velocity U-joint. It is a standard type U-joint as used on vehicle propeller shafts. However, some vehicles do use them on their front driving axles.



Questions

Match the following types of universal joints with their illustration.

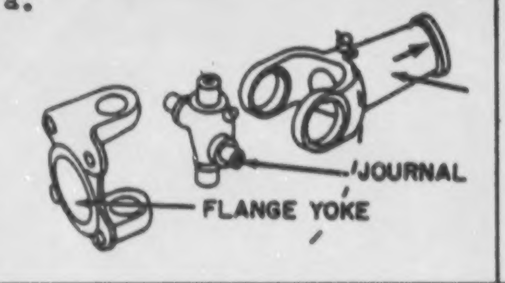
22. Bendix-Weiss constant velocity U-joint.

23. Rzeppa constant velocity U-joint.

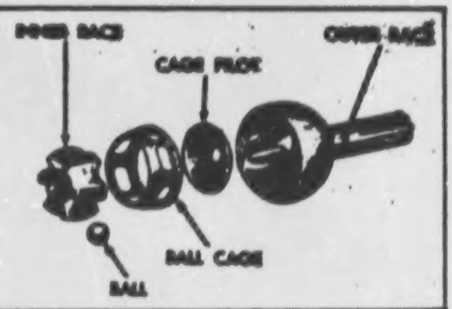
24. Tracta constant velocity U-joint.

25. NOT a constant velocity U-joint.

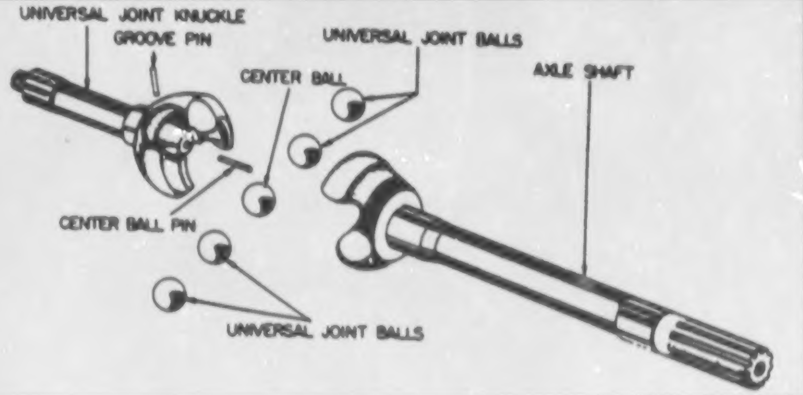
a.


JOURNAL
FLANGE YOKE

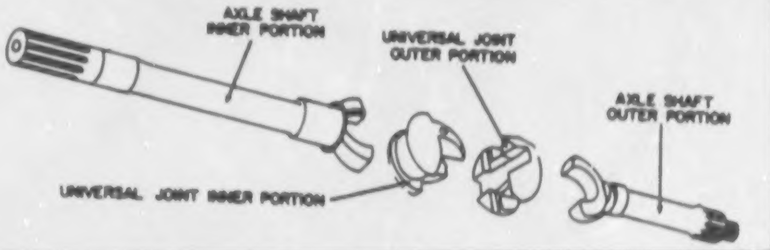
b.


INNER RACE
CAGE PILOT
OUTER RACE
BALL CAGE
BALL

c.


UNIVERSAL JOINT KNUCKLE
GROOVE PIN
UNIVERSAL JOINT BALLS
AXLE SHAFT
CENTER BALL
CENTER BALL PIN
UNIVERSAL JOINT BALLS

d.


AXLE SHAFT INNER PORTION
UNIVERSAL JOINT OUTER PORTION
AXLE SHAFT OUTER PORTION
UNIVERSAL JOINT INNER PORTION

Answer to question 22.	C
Answer to question 23.	B
Answer to question 24.	D
Answer to question 25.	A

PREPARE THE MAN

PROGRAMMED TEXT 3ABR47~~330~~232-PT-504A
3ABR47231-1-PT-604A
3ABR47231A-PT-604A
3ABR47231B-PT-604A
3ABR47231C-PT-604A

Technical Training

8-11

General Purpose Vehicle ~~Repairman~~ mechanic
Special Vehicle Repairman
(Towing and Servicing Vehicles)
(Crash/Fire Vehicles)
(Refueling Vehicles)
(Materials Handling Vehicles)

ANTI-SPIN DIFFERENTIAL

29 November 1971

CHANUTE TECHNICAL TRAINING CENTER (ATC)

This supersedes 3ABR47330-PT-504A, 29 December 1970.
OPR: TDWS
DISTRIBUTION: X
TDWS - 800; TTOC - 6

Designed For ATC Course Use

DO NOT USE ON THE JOB

FOREWORD

This programmed text was prepared for use in Course 3ABR47131 (now 47330) Automotive Repairman, in 1965. The materials contained herein were validated with 30 students from the subject course. All students used in the validation exercise achieved the objectives as stated. The text has been in continuous use for the past five years and has trained about 3500 students. The text is considered to be still valid.

OBJECTIVES

Upon completion of this programmed text you will be able to accomplish the following objectives with 80% accuracy.

1. Given a diagram of the anti-stin unit components, write the name of each component in the space provided by it.

2. State in your own words the main purpose of the anti-spin differential.

3. Describe the operation of an anti-spin differential.

INSTRUCTIONS

This programmed text was designed to be used in the Automotive Repairman course. It is written in small segments called frames. After each frame, you will be required to respond in some way to the information given. Follow the instructions after each frame and always check your answers which are located at the top of the next page. If you need assistance, your instructor will be nearby to help you.

In the conventional differential, the torque to the two axles is evenly divided at all times. A fault of the conventional differential is that if one driving wheel loses traction and spins, the other wheel which has more traction remains stationary and does not drive the vehicle.

QUESTIONS

Indicate whether the following statements are true or false.

___ 1. Equal traction is supplied to both rear wheels.

___ 2. The wheel with the greatest traction will spin when power is applied.

___ 3. Power to a conventional differential is always the same to both axles.

Answers to Frame 1.

1. F   2. F   3. T

Frame 2

The main purpose of the anti-spin differential is to supply a greater percentage of the driving torque to the wheel with the best traction and still furnish the wheel with poorer traction as much torque as it is able to absorb.

QUESTIONS

Indicate whether each of the following statements are true or false.

___ 4. Both wheels receive the same torque regardless of traction.

___ 5. The greatest power goes to the wheel that can use it best.

___ 6. The wheel with the poorer traction is provided some power.

Answers to Frame 2.

4. F   5. T   6. T

Frame 3

The anti-spin differential prevents "shock loads" or full engine torque from being transmitted to only one axle shaft. It provides power to both rear wheels and also maintains the differential action that is needed when the vehicle is turning a corner, that is, it permits the outer wheel to turn faster than the inner wheel.

QUESTIONS

Indicate whether each of the following statements are true or false.

The anti-spin differential

___ 7. has the same ability, in turns, as a conventional differential.

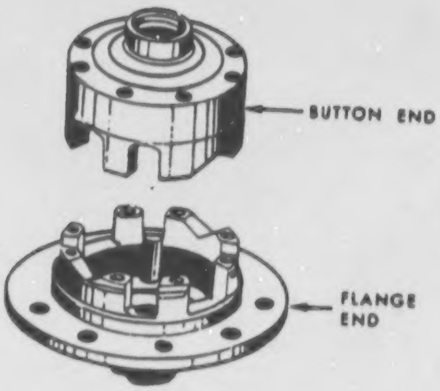
___ 8. provides power to both axle shafts at the same time.

___ 9. only provides power to the axle shaft with the greatest traction.

Answers to Frame 3.

7. T   8. T   9. T

Frame 4



This is the case for an anti-spin differential.

Fill in the blank spaces with the correct word.

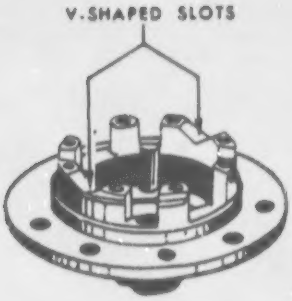
10. The case for an anti-spin differential is made in ____________ (number) parts.

11. They are referred to as the __________ and the _________ end.

Answers to Frame 4.

10. two 11. button and flange

Frame 5



On each half (end) of the case, are two (2) V-shaped slots.

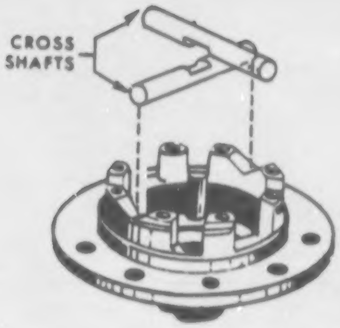
Fill in the correct word.

12. The illustration above pictures the __________ end of the differential case. On each end of the case there are two _____ shaped slots.

Answers to Frame 5.

12. flange and "V"

Frame 6



A cross shaft rests on these V-shaped slots. This cross shaft is not rigidly fastened together.

Cross out the incorrect word.

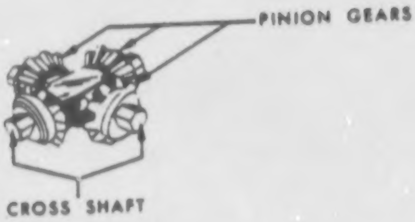
13. The cross shaft is/is not rigidly fastened together.

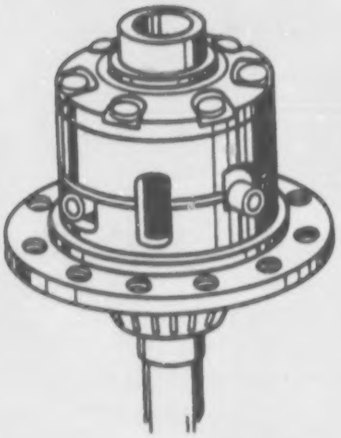
Answer to Frame 6.

13. is not

Frame 7

Each cross shaft has two pinion gears on it.


PINION GEARS
CROSS SHAFT



Case with pinion cross shaft in place.

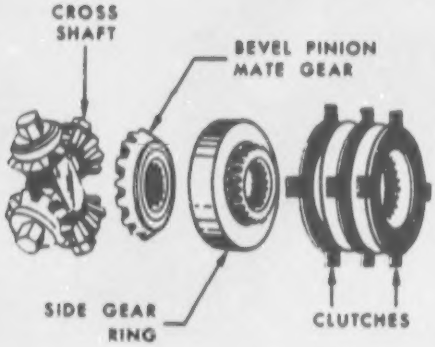
Fill in the correct word.

14. The anti-spin differential has _________ (number) pinion gears mounted on a _____________ _____________.

Answers to Frame 7.

14. four, cross shaft

Frame 8


CROSS SHAFT
BEVEL PINION MATE GEAR
SIDE GEAR RING
CLUTCHES

On each side of the pinoin cross shafts are

1. a bevel pinion mate gear.
2. a side ring gear.
3. clutches.

Fill in the correct word.

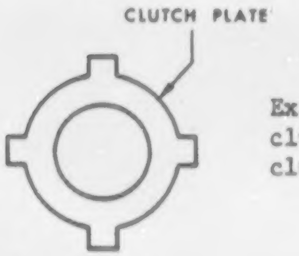
15. In the illustration above, the bevel pinoin mate gear is in mesh with the ___________ gears.

Answer to Frame 8.

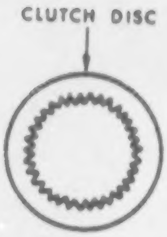
15. pinion.

Frame 9

There are two different types of clutches.



Externally splined clutches called clutch plates.



Internally splined clutches called clutch discs.

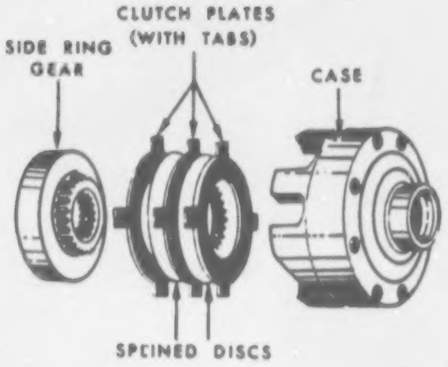
Fill in the correct word.

16. There are two different types of ____________. They are called clutch _______________ and clutch ______________.

Answers to Frame 9.

16. clutches, plates, disc

Frame 10


CLUTCH PLATES (WITH TABS)
SIDE RING GEAR
CASE
SPLINED DISCS

Two of the clutch discs are splined to the outer splines of the side ring gear. They spin freely, until pressed between the clutch plates, which are held to the differential case by tabs.

Fill in the correct word.

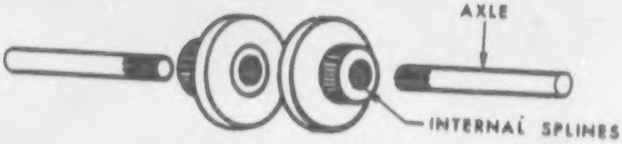
17. Clutch plates are splined to the differential ____________.
Clutch __________ are splined to the side ring gear.

Answers to Frame 10.

18. case, discs

Frame 11

The axle fits into the internal splines cut into the side ring gear.


AXLE
INTERNAL SPLINES

Fill in the correct words.

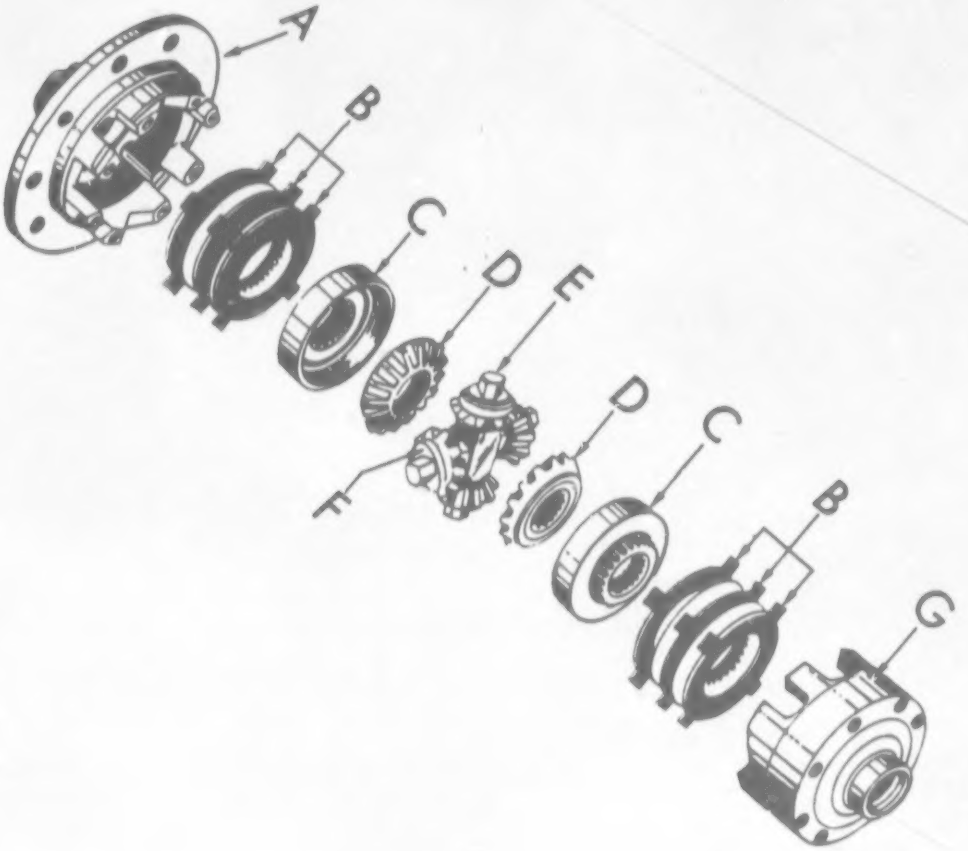
19. The axles are driven by the ____________ ______________ ___________.

Answer to Frame 11.

19. side ring gear

Frame 12

Now that we have covered all of the components of an anti-spin differential, let's put them all in their proper places. Below is presented an exploded view of the anti-spin unit. The rear axles slide through the openings in the end of the case, through the clutch discs, and mate with the internal splines of the side ring gear.



Identify the lettered components.

20. A. ______________ E. ______________

B. ______________ F. ______________

C. ______________ G. ______________

D. ______________

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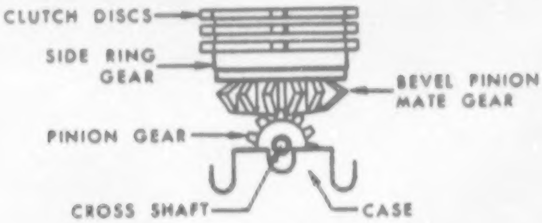
Answers to Frame 12.

20. A. Flange end (dif case)
C. Side ring gear
E. Cross shaft
G. Button end (differential case)
B. Clutches
D. Bevel pinion mate gear
F. Pinion gear

Frame 13

The flange end of the anti-spin case is bolted to the ring gear of the differential. As the drive shaft of the vehicle begins to turn, the anti-spin case also starts rotating. Resistance of the wheels causes the cross shafts to ride up the V-shaped ramps, and puts pressure on the clutch discs. This locks the discs together and both rear wheels turn as if the axles were one solid shaft.


CLUTCH DISCS
SIDE RING GEAR
BEVEL PINION MATE GEAR
PINION GEAR
CROSS SHAFT
CASE

21. What causes the clutch disc to lock together?
(Write your answer below.)

Answer to Frame 13.

21. Resistance of the wheels causes the cross shafts to ride up the V-shaped ramps and squeeze the clutches together.

Frame 14

When the vehicle is turning, the rear wheel on the outside of the turn must travel further than the inside wheel. In order to do this, it must travel faster. As the vehicle starts around the turn, and the outside wheel speeds up, the torque created by this increase in speed allows the cross shaft (acting on the outside wheel) to ride back down the V-shaped ramp and release the pressure on the clutch discs. This allows the outside wheel to ride free in a turn.

Fill in the correct word.

22. The anti-spin differential must act as a conventional differential when the vehicle is ________________.

Answer to Frame 14.

27. turning

Frame 15

To summarize anti-slip differential operation, it can be said that during straight forward or rearward operation both friction clutches are engaged to provide equal torque to both rear wheels; in a turn, however, the outside wheel turns faster than the inside wheel and this causes one friction clutch to disengage (the clutch that controls the torque to the outside wheel of the turn) to provide operational similar to that of the conventional differential during the turn.

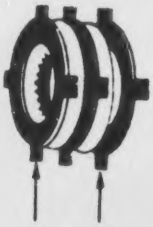
Straight rearward operation is the same as forward operation except that all motion is reversed and the cross pins move up the opposite cam surfaces.

When disassembling or reassembling an anti-spin differential, there are several important items to remember.

1. Before disassembly, scribe the two halves of the case so that they will be reassembled correctly.

2. After the case bolts are removed, all internal parts will "fall" out when the case halves are separated.

3. When replacing the clutches, the concave "tabbed" plates are always placed with the other discs between them and cupped toward these discs.



4. Before tightening the case bolts (when reassembling), slide the axles into the case and align the splines of the side ring gear. If this is not done, you may not be able to insert the axles after the case has been replaced in the differential housing.

Continue to the self test on the following page.

Circle your answers to the following questions and/or problems.

1. A scribe mark should be placed on the case of the anti-spin differential prior to

   a. removal.
   b. disassembly.
   c. reassembly.

2. A friction clutch disengages when

   a. driving in reverse.
   b. accelerating rapidly on a slick surface.
   c. one wheel turns faster than the other.

3. The purpose of the anti-spin differential is to

   a. cause both wheels to turn at the same speed when turning.
   b. provide the most torque to the wheel with the least resistance and differential action in turns.
   c. provide the most torque to the wheel offering the best traction and differential action in turns.

4. Full torque is transmitted to both wheels when

   a. both clutches are engaged.
   b. both clutches are disengaged.
   c. either clutch is engaged.

5. When both cross pins move "up" the ramp on the cam surfaces, both clutches

   a. engage to restrict differential action.
   b. disengage to allow differential action.
   c. engage to allow differential action.

6. When one cross pin moves "up" the ramps of the cam surfaces

   a. one clutch engages and the other disengages.
   b. both clutches engage to restrict differential action.
   c. both clutches disengage to restrict differential action.
   d. both clutches disengage to allow differential action.

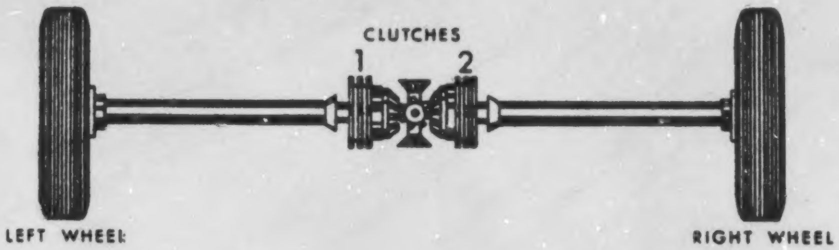
Indicate whether each of the following statements are true or false.

___ 7. Rearward operation of anti-spin differentials does not reduce their effectiveness.

___ 8. During rearward operation, both clutches disengage to restrict differential action.

___ 9. During rearward operation, both clutches engage to restrict differential action.

Using the drawing below, complete the following statements.


CLUTCHES
1
2
LEFT WHEEL
RIGHT WHEEL

10. In a right turn, clutch #1 is (a)__________ and clutch #2 is (b)____________________.

11. In a left turn, clutch #1 is (a)___________ and clutch #2 is (b)____________________.

12. During straight forward or rearward operation, clutch #1 is (a)_________________ and clutch #2 is (b)_________________.

Answers to self test.

1.	B
2.	C
3.	C
4.	A
5.	A
6.	A
7.	True
8.	False
9.	False
10.(a)	Disengaged
10.(b)	Engaged
11.(a)	Engaged
11.(b)	Disengaged
12.(a)	Engaged
12.(b)	Engaged

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PROGRAMMED TEXT 3ABR47330-PT-505

3ABR47231-1-PT-404B
3ABR47231A-PT-404B
3ABR47231B-PT-404B
3ABR47231C-PT-404B

Technical Training

General Purpose Vehicle Repairman
Special Vehicle Repairman
(Towing and Servicing Vehicles)
(Crash/Fire Vehicles)
(Refueling Vehicles)
(Materials Handling Vehicles)

8-11

AUTOMATIC TRANSMISSIONS

18 March 1974

CHANUTE TECHNICAL TRAINING CENTER (ATC)

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Designed For ATC Course Use

INTRODUCTION

This text is designed to assist you in learning the basic principles of automatic transmissions. It contains the components of automatic transmissions and their relation to one another. However, no effort is made to teach construction, design, or maintenance of a particular transmission.

OBJECTIVES

Upon completion of this text you will be able to accomplish the following objectives with 85% accuracy.

1. Define the terms: torque - reduction - reverse reduction - direct drive.

2. List the three basic hydraulic principles involved in the operation of automatic transmissions.

3. List the components and their purpose of a basic oil pressure system.

4. Label the parts of a simple planetary gear unit in a diagram.

5. List the three functions of a planetary gear unit.

6. List two rules that apply to the control of a simple planetary gear unit.

7. List the component that holds a member of the planetary gear unit.

8. List the device that is used to control a band.

9. List the component that locks two members of a planetary gear unit together.

10. State how a multiple-disc clutch is applied and released.

11. State the purpose of the governor and what drives it.

12. State the purpose of the throttle valve and what controls it.

13. State the operating principles of the fluid coupling.

14. List the parts of the torque converter and the function of each part.

15. Given a diagram that illustrates a two-speed transmission, draw in the flow of mainline and variable pressures that will complete the upshift from low to high gear.

16. State the difference between a simple and a compound planetary gear system.

There are certain basic terms that are used by all persons who work with power trains. In order to put everyone on "common ground," it is necessary to define these terms so everyone will get the same picture or meaning when the term is used.

1. Torque - a twisting force.

2. Reduction - a torque increase with a speed decrease. (Example: In a standard transmission in low gear the torque at the output shaft will be greater than that of the input shaft, but the speed of the output shaft will be slower than that of the input shaft. Consequently, we have given up speed for power.)

3. Reverse reduction - a torque increase with a speed decrease, in the opposite direction. (Example: A car backing up - It has great power in reverse, but its speed is limited.)

4. Direct drive - a 1 to 1 gear ratio. (Example: In a vehicle traveling in high gear, the input and output shafts are both turning at the same speed.

5. Overdrive - any gear ratio higher than 1:1. (Example: 1:2, 1:3, 1:5, etc.) Converting engine torque to a faster but less powerful working force.

6. Neutral - input, but no output. Gears in the transmission which are in constant mesh with the input are idling. (Turning but not transmitting power.)

QUESTION 1

Match the gear ratio with the proper term.

1. 3:1
2. 2:1
3. 1:0
4. 1:2
5. 3:4
6. 30:10
7. 1:1

A. Reduction
B. Direct drive
C. Overdrive
D. Neutral

ANSWERS TO QUESTION 1

1. A 2. A 3. D 4. C 5. C 6. A 7. B

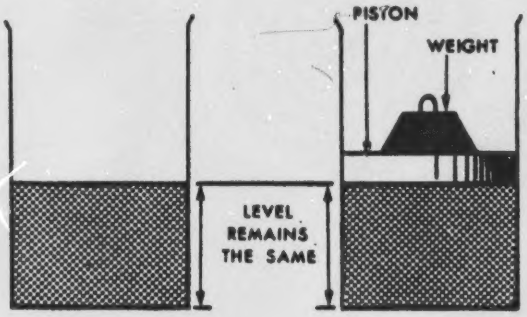
Frame 2

HYDRAULIC PRINCIPLES

The automatic transmission utilizes hydraulic pressure in its operation. Automatic transmission fluid is used to transmit the hydraulic pressure to the different parts of the transmission to affect output shift speed and direction changes.

The operation of automatic transmissions is based largely upon three (3) hydraulic principles.

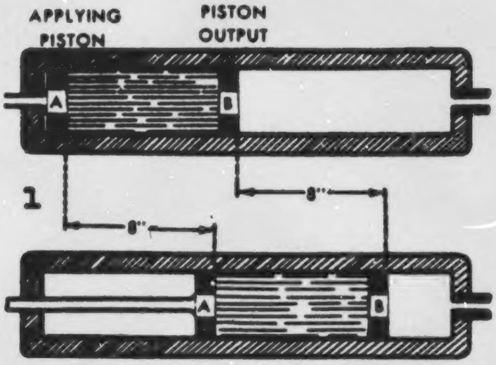
PRINCIPLE NUMBER ONE
LIQUID CANNOT BE COMPRESSED



In the illustration above, notice that the level of the liquid in the two containers remains the same when weight is placed on the liquid in one and not on the other. This weight, or pressure, did not reduce the volume of the liquid. This means that:

LIQUIDS CANNOT BE COMPRESSED.

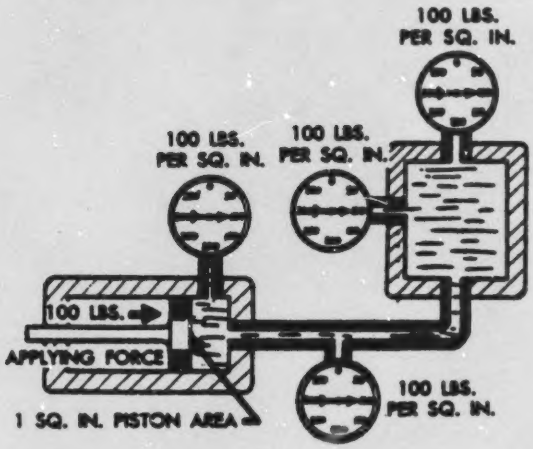
PRINCIPLE NUMBER TWO
MOTOR CAN BE TRANSMITTED BY LIQUID



In the above diagram, notice that when pressure moves piston "A," the liquid separating the pistons moves piston "B" the same distance. This means that:

MOTION CAN BE TRANSMITTED BY LIQUID.

PRINCIPLE NUMBER THREE
LIQUID UNDER PRESSURE TRANSMITS PRESSURE EQUALLY IN ALL DIRECTIONS


100 LBS.
PER SQ. IN.
100 LBS.
PER SQ. IN.
100 LBS.
PER SQ. IN.
100 LBS.
APPLYING FORCE
1 SQ. IN. PISTON AREA
100 LBS.
PER SQ. IN.

In the above diagram, notice that the applying force of 100 lbs. exerts 100 lbs. of pressure on the liquid at all gauges, regardless of the location or size of the passages to which the gauges are attached. This means that:

LIQUID UNDER PRESSURE, TRANSMITS
PRESSURE EQUALLY IN ALL DIRECTIONS.

QUESTION 2

Fill in the words missing from the principles listed below.

a. Liquid cannot be ____________.

b. Motion can be ____________ by liquid.

c. Liquid under pressure transmits pressure ____________ in all ____________.

ANSWERS TO QUESTION 2:

a. compressed

b. transmitted

c. equally in all directions

Frame 3

From previous learning experiences you found that the purpose of any transmission was to provide different gear ratios and a reversing capability through the use of different gear arrangements. As you know, a standard transmission requires manual shifting of the gears to provide the different forward speeds and reverse capability. In the automatic transmission, the gears are never shifted, and yet the automatic transmission will provide these same things. This is accomplished through the use of a gear unit that is greatly different from the gears used in standard transmissions and the manner in which the gear unit is controlled.

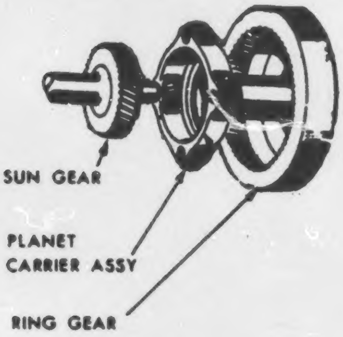
This next part of the lesson will explain the gear unit, its controls, and how it transmits torque from the drive unit to the rear wheels.

The gears of the standard transmission, as you know them from past learning experiences, cannot be used in the automatic transmission. All automatic transmissions must utilize a gear unit which is capable of providing forward speeds as well as a reverse feature without the shifting of gears. The type of gear unit used is called a planetary gear unit.

NO RESPONSE REQUIRED

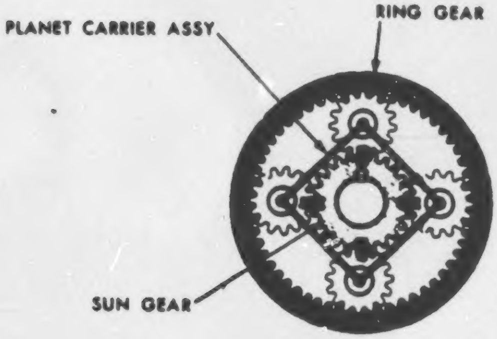
A SIMPLE PLANETARY GEAR UNIT

SIDE VIEW OF
PLANETARY GEAR UNIT
WITH MEMBERS SEPARATED.



This is a simple planetary gear unit. Compound gear units will be presented in later lessons. For ease of understanding only simple gear units will be discussed in this lesson.

END VIEW OF PLANETARY GEAR UNIT
WITH THE MEMBERS ASSEMBLED.



The gears of the planetary gear unit are never changed from the arrangement you see in the end view diagram shown above. You can see that the gears all have one center of rotation, and that they are in constant mesh with one another.

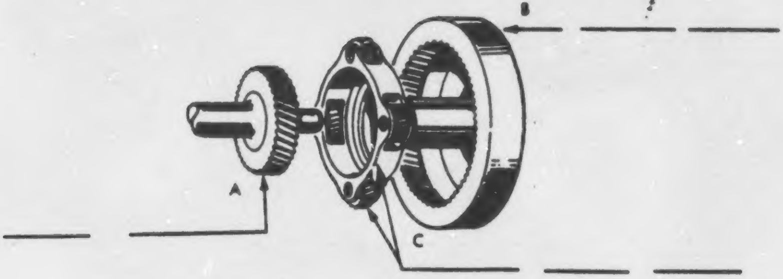
This planetary gear unit has three (3) members:

1. Ring gear - Has internal teeth and is in constant mesh with the planet gears.
2. Planet Carrier Assy - Have external teeth and are in constant mesh with both ring gear and sun gear. The planet carrier is considered to be part of the planet gears as they are permanently fixed together.
3. Sun gear - Has external teeth and is in constant mesh with the planet gears.

The planetary gear unit gets its name from, and can be easily compared to our solar system. Planets (planet gears) revolve around the sun (sun gear) just as in our own solar system. The ring gear may be thought of as the force that holds the planets of the solar system in place in that it surrounds the other gears of the planetary gear unit.

QUESTION 3

Identify the members of the gear unit below by filling in the spaces provided by the arrows.



ANSWERS TO QUESTION 3

A Sun Gear B Ring Gear C Planet Carrier Assy

Frame 5

It was stated previously that the planetary gear unit is capable of providing forward speeds and reverse just as the different gear arrangements of the standard transmission will provide. Before going into how this is accomplished, let's find out just what the planetary gear unit will do.

The planetary gear unit when properly controlled will produce

1. GEAR REDUCTION - low or second gear same as in a standard transmission.

2. REVERSE REDUCTION - reverse gear same as in a standard transmission.

3. DIRECT DRIVE - high gear same as in a standard transmission.

There are the two rules which apply to the control of the planetary gear unit.

1. Anytime we apply power to one member, hold one member, and take power from the third member, the gear unit will produce a gear reduction and/or a reverse of direction.

2. Anytime we lock two members together the gear unit will produce direct drive.

QUESTION 4

Fill in the blank spaces with the correct terms.

a. To obtain gear reduction and/or reverse from a planetary gear unit, it is necessary to ____________ ____________ to one member, ____________ one member, and ____________ ____________ from the third.

b. To obtain direct drive from a planetary gear unit, it is necessary to ____________ ____________ members ____________.

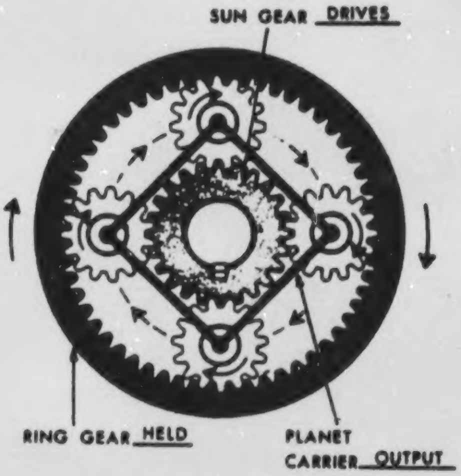
ANSWERS TO QUESTION 4:

a. apply power, hold, take power

b. lock two, together

Frame 6

Proper control of the members determines the output of the planetary gear unit. The diagrams on this and the next three frames illustrate four of the possibilities the planetary gear unit is capable of producing with the proper control. As you study the functions of the gear unit, compare the action described below each diagram to the illustrated action of the diagram. One specific thing that you must remember while studying these diagrams is that the gears of a pleantary gear unit are in constant mesh.



In this illustration consider the sun gear as being connected to the input shaft.

1. Power is applied to the sun gear by the input shaft.

2. The sun gear drives the planet gears in the same direction.

3. The ring gear is held, forcing the planet gears to walk around the ring gear causing the planet carrier to turn in the same direction as the sun gear.

4. Power is taken from the planet carrier which is connected to the output shaft.

The planet carrier, which is connected to the output shaft, is turned slower than the sun gear which is attached to the input shaft, thereby producing a maximum reduction. This would be similar to 1st speed in a transmission.

QUESTION 5

Maximum reduction is achieved when the ____________ ____________ drives, ____________ ____________ is held, and ____________ ____________ is the output.

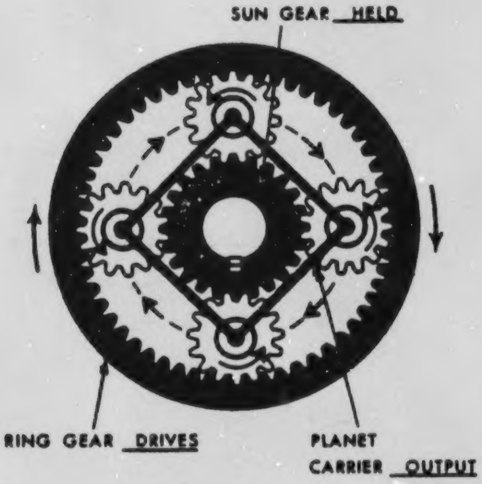
ANSWERS TO QUESTION 5:

sun gear, ring gear, planet carrier

Frame 7

MINIMUM REDUCTION

Arrows indicate direction of gear rotation



In this illustration consider the ring gear as being connected to the input shaft.

1. Power is applied to the ring gear by the input shaft.

2. The ring gear drives the planet gears in the same direction.

3. The sun gear is held, forcing the planet gears to walk around the sun gear and the planet carrier to turn in the same direction as the ring gear.

4. Power is taken from the planet carrier which is connected to the output shaft.

The planet carrier, which is connected to the output shaft, is turned slower than the ring gear which is attached to the input shaft, thereby producing minimum reduction. This would be similar to second speed in a transmission.

QUESTION 6

When the sun gear is held and the ring gear drives, ____________ reduction is achieved.

ANSWER TO QUESTION 6

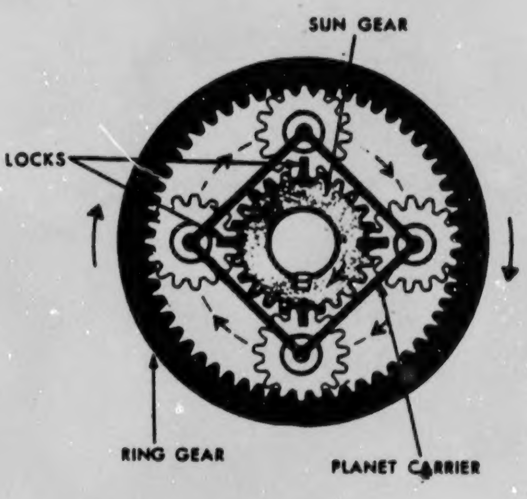
minimum

Frame 8

DIRECT DRIVE

Arrows in diagram indicate direction of gears

Locks are for illustration purposes only, the actual device used to lock members together is a clutch which will be covered in a later lesson.



In the above illustration, consider that the sun gear is connected to the input shaft. (However, any one of the members could be connected to the input shaft.)

1. Power is applied to the sun gear by the input shaft.

2. The sun gear and the planet gears are locked together.

3. The sun gear turns the planet gears and the ring gear at the same speed - due to lock up, none of the gears can turn independently.

4. The planetary gear unit will now turn as a unit, or just like a straight-through shaft.

5. Power is taken from the ring gear which is connected to the output shaft.

The ring gear, which is connected to the output shaft, is turned at the same speed as the sun gear which is driven by the input shaft, thereby producing direct drive. Direct drive in the automatic transmission is also known as high gear just as in the standard transmission.

QUESTION 7

When all members of the planetary gear system are locked together, the unit is in ___________.

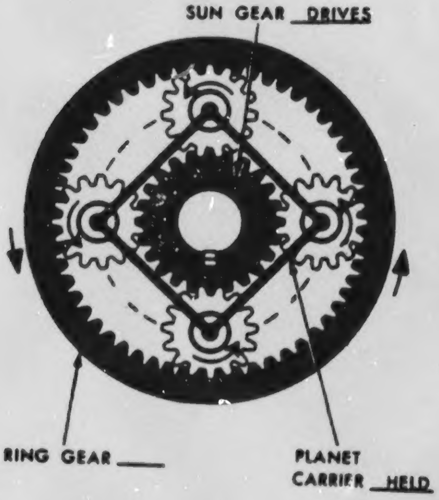
ANSWER TO QUESTION 7

direct drive (high gear would have been acceptable)

Frame 9

REVERSE

Arrows in diagram indicate direction of gears



In the illustration above, consider the sun gear as being connected to the input shaft.

1. Power is applied to the sun gear by the input shaft.

2. The sun gear drives the planet gears in the opposite direction.

3. The planet carrier is held and cannot rotate with the planet gears. With the planet carrier being held, the planet gears must turn in place about their center pins. The planet gears are actually acting as idlers, the same as the reverse idler in a standard transmission.

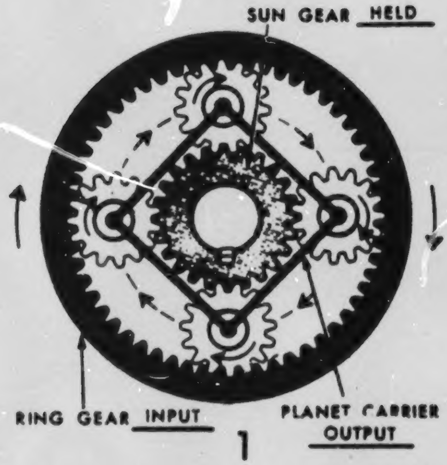
4. The planet gears turning in place drive the ring gear in the opposite direction from the sun gear.

5. Power is taken from the ring gear which is connected to the output shaft.

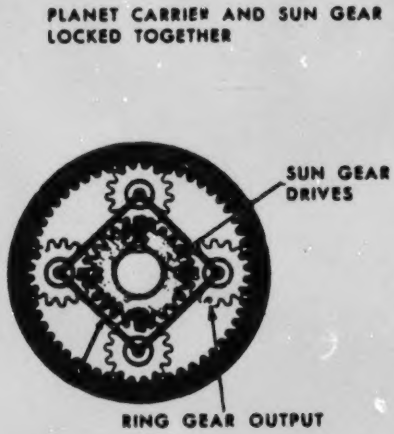
The ring gear, which is connected to the output shaft, is turned in a direction in reverse from that of the sun gear, which is connected to the input shaft, thereby producing reverse.

QUESTION 8

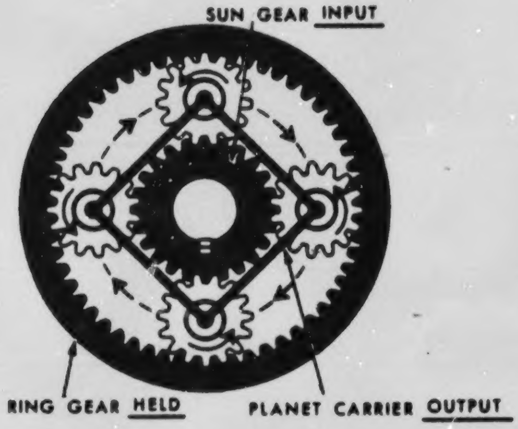
Determine what each of the planetary gear units pictured below is producing.


SUN GEAR HELD
RING GEAR INPUT
PLANET CARRIER OUTPUT

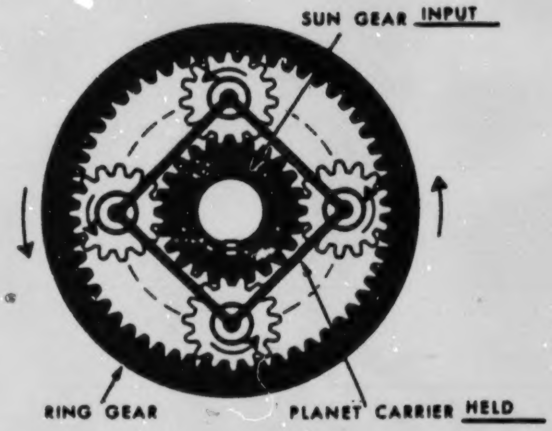
1


PLANET CARRIER AND SUN GEAR LOCKED TOGETHER
SUN GEAR DRIVES
RING GEAR OUTPUT

2


SUN GEAR INPUT
RING GEAR HELD
PLANET CARRIER OUTPUT

3


SUN GEAR INPUT
RING GEAR
PLANET CARRIER HELD

4

1. ______________________

2. ______________________

3. ______________________

4. ______________________

ANSWER TO QUESTION 8

1. Minimum Reduction.
2. Direct Drive.
3. Maximum Reduction.
4. Reverse Reduction.

Frame 10

As you know, the planetary gear unit is vastly different in construction and operation from the gears used in standard transmissions. Due to this difference, the planetary gear unit has many advantages over the gears used in standard transmissions. These advantages are listed below with a comparison made to the gear arrangement of the standard transmission. Read one advantage at a time - read the corresponding comparison - then through the use of the illustration on the next page, compare the planetary gear unit to the standard transmission gear arrangement.

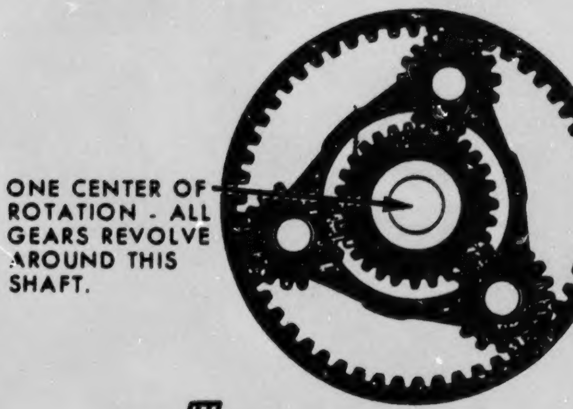
ADVANTAGES

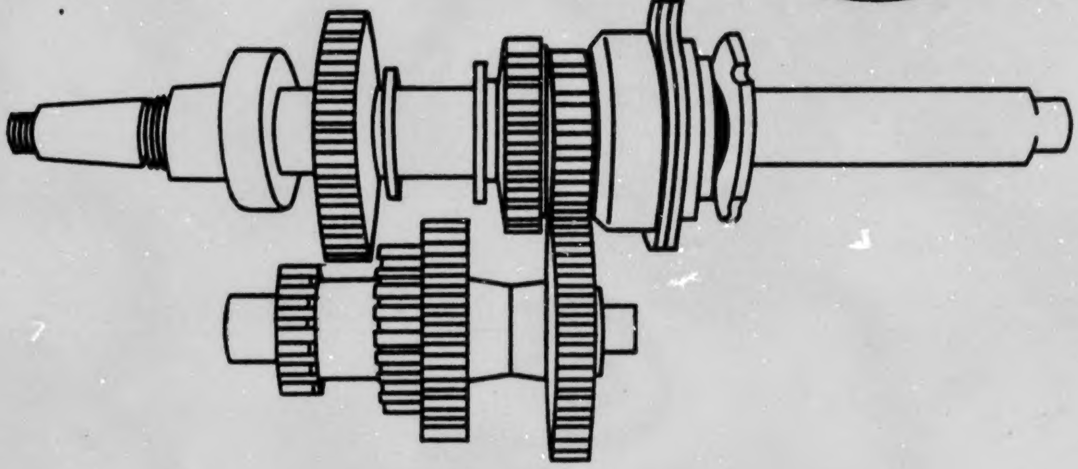
Advantages of planetary gears over standard sliding gears.

1. Constant mesh. They never have to be shifted.
2. Stronger. More tooth contact.
3. One common center of rotation. Mounted on one shaft.
4. Control. Easy to control hydraulically.

Note: Refer to the illustration on the next page while making these comparisons.

ILLUSTRATION PANEL


ONE CENTER OF ROTATION - ALL GEARS REVOLVE AROUND THIS SHAFT.



QUESTION 9

List four advantages of planetary gears.

a. ______________________________

b. ______________________________

c. ______________________________

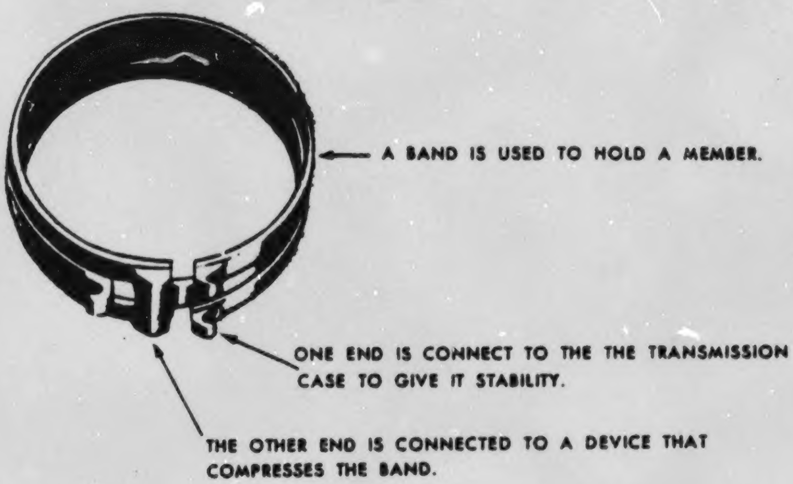
d. ______________________________

ANSWERS TO QUESTION 9

a. Constant mesh
b. Stronger
c. One common center of rotation
d. Control

Frame 11

You have learned that the control placed on a planetary gear unit determines its output, and that one means of control is to hold a member.


A BAND IS USED TO HOLD A MEMBER.
ONE END IS CONNECT TO THE THE TRANSMISSION CASE TO GIVE IT STABILITY.
THE OTHER END IS CONNECTED TO A DEVICE THAT COMPRESSES THE BAND.

The band is made of spring steel (to enable it to return to its original shape after having been compressed) and it has a lining for strength and durability which is made of pressed paper with metal particles embedded.

The band has the same general appearance as a handbrake band used on vehicles equipped with a propeller shaft handbrake.

QUESTION 10

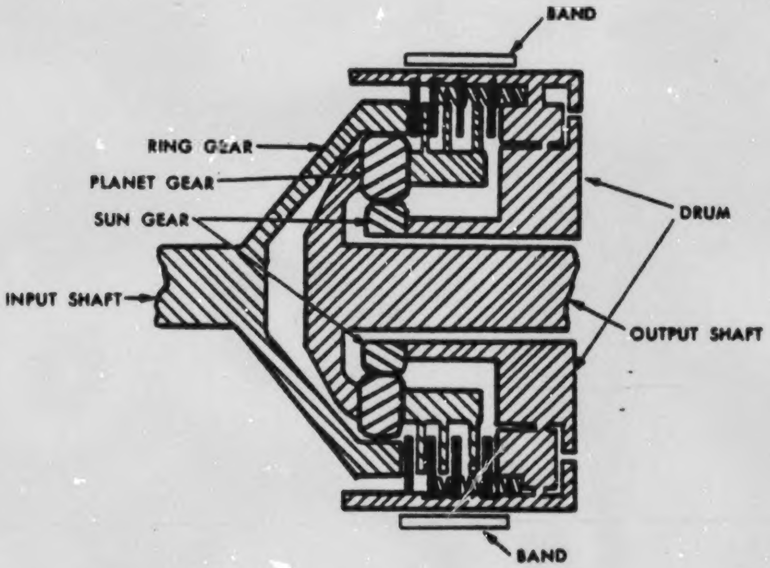
What is used to hold a member of a planetary gear unit? ________________

ANSWER TO QUESTION 10

A band.

Frame 12

The members of a planetary gear unit which are controlled by a band will always have a drum affixed to them. In the illustration below, the band is wrapped around the drum fixed to the sun gear. When this band is applied, it holds the sun gear which produces minimum reduction.


BAND
RING GEAR
PLANET GEAR
SUN GEAR
INPUT SHAFT
DRUM
OUTPUT SHAFT
BAND

Planetary Gear Unit set up for minimum reduction

QUESTION 11

a. What does the automatic transmission utilize as a holding device to control a member of the planetary gear unit? ______________________

b. Of what is the holding device made? ______________________

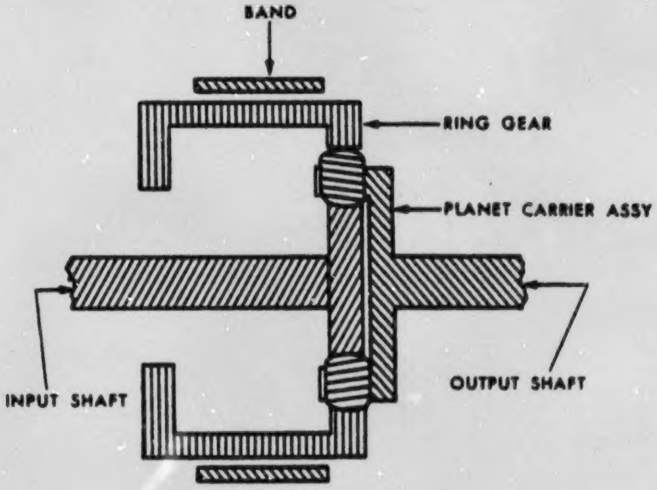
c. What type of reduction does the planetary gear unit illustrated above produce? ______________________

ANSWERS TO QUESTION 11

a. band
b. pressed paper lined spring steel
a. minimum reduction

Frame 13

In the illustration below, the band is wrapped around the drum fixed to the ring gear. When this band is applied, it holds the ring gear which produces a maximum reduction.


BAND
RING GEAR
PLANET CARRIER ASSY
INPUT SHAFT
OUTPUT SHAFT

Planetary Gear Unit set up for maximum reduction

QUESTION 12

In the above illustration:

a. What planetary gear is being held by a band?

b. What planetary gear is on the input shaft?

c. What unit delivers power to the propeller shaft?

Place your answers below.

a. ______________________________

b. ______________________________

c. ______________________________

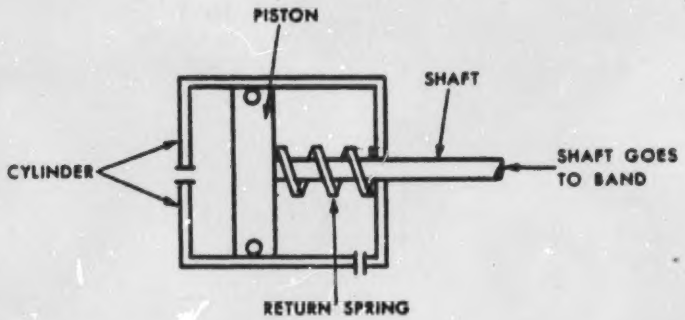
ANSWERS TO QUESTION 12

a. ring gear
b. sun gear
c. planet carrier assembly

Frame 14

The band is controlled (compressed or released) by a device called a "servo." The servo is a hydraulically-controlled cylinder that is mounted solidly to the transmission case. The construction of the servo and its operation is similar to that of the hydraulic brake wheel cylinder.

Study the illustration below as you read the descriptions of the parts of the servo.



CYLINDER - Houses the parts of the servo and is sometimes called the "servo body."

PISTON - Pressure-fits the walls of the cylinder (like the cups in a brake wheel cylinder) and is moved by hydraulic pressure.

SHAFT - Connects the moveable piston to the band.

RETURN SPRING - Returns the piston when pressure is not being applied.

QUESTION 13

a. The ____________ is used to control the band.

b. The servo is controlled by a ____________ ____________.

c. The function of the servo is to ____________ and ____________ its band.

ANSWERS TO QUESTION 13

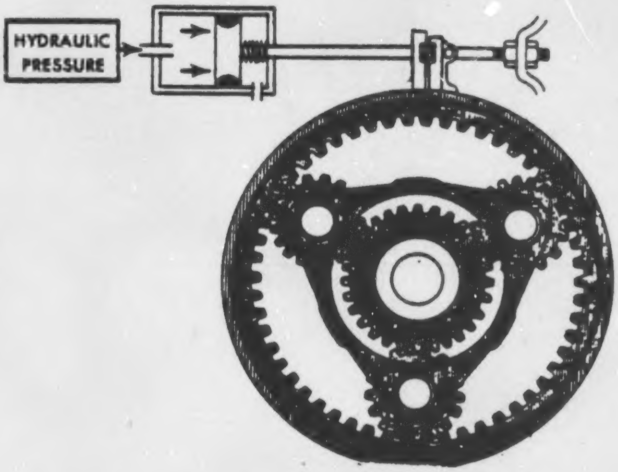
a. servo
b. hydraulic pressure
c. compress, release

Frame 15

You have read that a hydraulically-controlled servo controls the operation of the band. Now, let's put the two units together. The diagrams on this and the next frame illustrate the combined action of the servo and the band as a member of the planetary gear unit is held and then released.

The illustration below shows the combined action of the servo and band as a member of the planetary gear unit is held. Study the drawing as you read each step listed below the figure. These steps explain the action of the servo and the band.

ACTION OF SERVO COMPRESSING BAND



1. Hydraulic pressure is applied at the head of the servo piston.
2. The piston and shaft move, compressing the return spring.
3. The moving shaft compresses the band.
4. The compressed band holds the member (in this case, the internal gear).

Hydraulic pressure, acting on the servo, has applied the band.

QUESTION 14

Fill in the blank space with the correct term:

a. Bands are applied by ____________ pressure.

b. Bands are released by ____________ pressure.

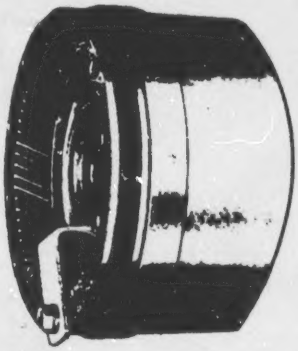
ANSWERS TO QUESTION 14

a. hydraulic
b. spring

Frame 16

You have learned that the control placed on the members of the planetary gear unit determine the output. One of these controls is the band used to hold a member to bring about either a gear reduction or reverse action. The other means of control is to lock two members together in order to obtain direct drive.

A clutch is used to provide the control required to lock any two members together. The only comparison between this clutch and the clutch used with the standard transmission is that they are both friction type clutches. That is, friction between two or more clutch members will provide a solid connection. The illustration below shows an assembled multiple disc clutch.



The multiple disc clutch is applied by hydraulic pressure acting upon the piston.

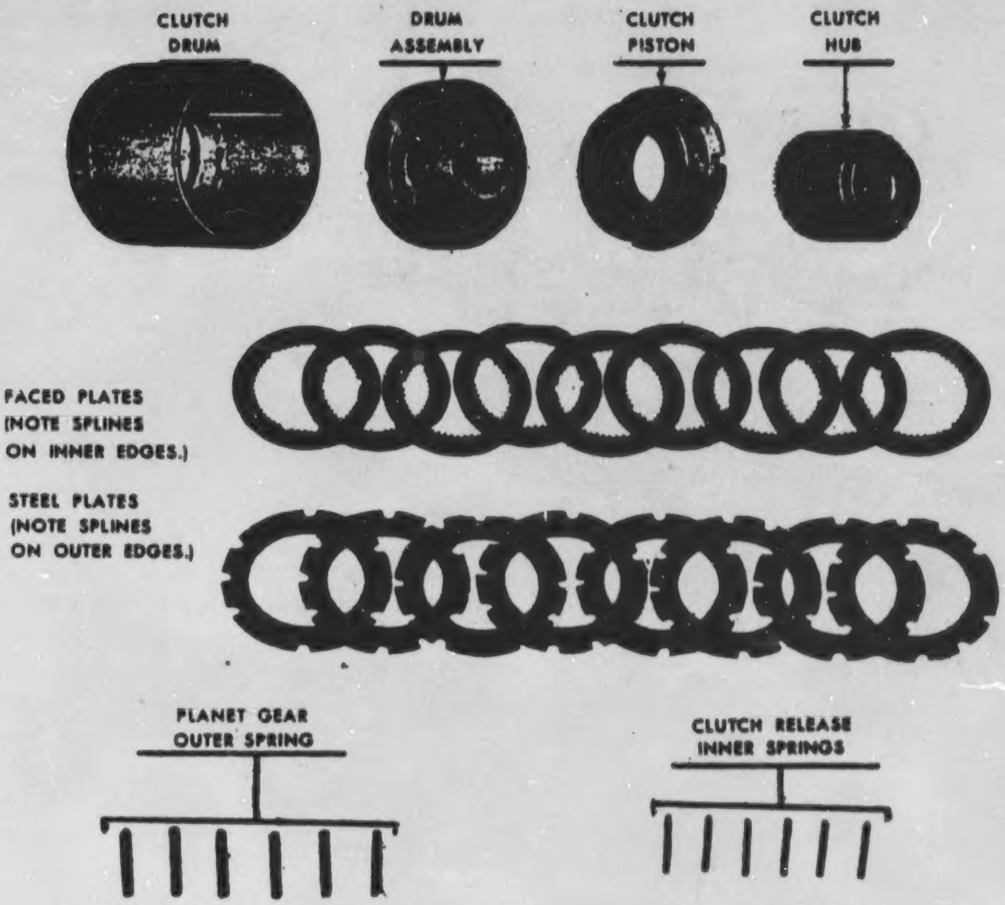
The multiple disc clutch is released by spring pressure which is provided by the clutch release springs.

An exploded view of the multiple disc clutch is shown in the next frame.

NO RESPONSE REQUIRED

Frame 17

THIS IS A MULTIPLE-DISC CLUTCH (EXPLODED VIEW)


CLUTCH DRUM
DRUM ASSEMBLY
CLUTCH PISTON
CLUTCH HUB
FACED PLATES (NOTE SPLINES ON INNER EDGES.)
STEEL PLATES (NOTE SPLINES ON OUTER EDGES.)
PLANET GEAR OUTER SPRING
CLUTCH RELEASE INNER SPRINGS

As you can see, the clutch consists of numerous plates. This is why it is called a multiple-disc clutch. The steel plates are attached indirectly (by the notches) to a member of the planetary gear unit, and the faced plates are indirectly attached (by the splines) to another member. Remember, the clutch plates are always indirectly attached to two members of the planetary gear unit.

QUESTION 15

a. What is the purpose of the multiple-disc clutch?

b. Why is the unit called a multiple-disc clutch?

Write your answers in the blanks below.

a. ______________________________

b. ______________________________

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ANSWERS TO QUESTION 15

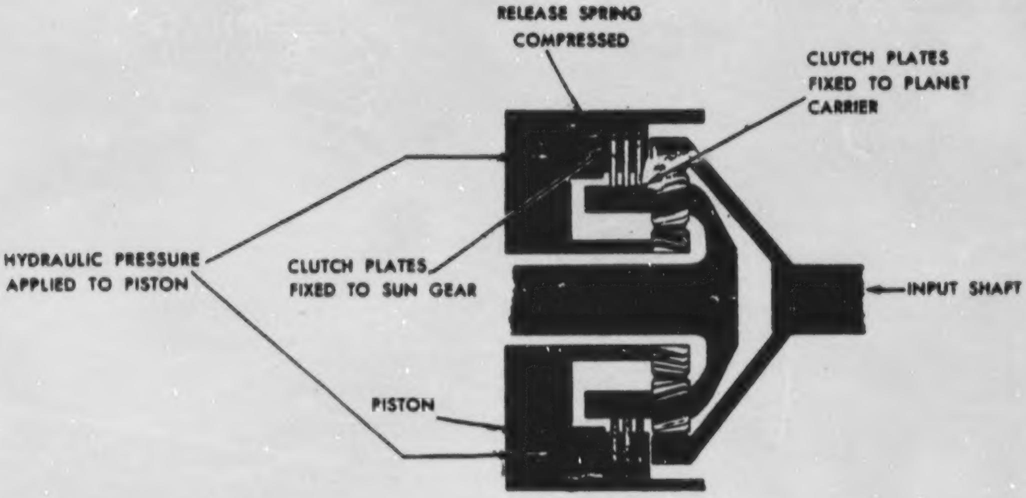
a. Lock two members of the planetary gear unit together

b. Because it consists of numerous plates.

Frame 18

By now you know that a multiple-disc clutch is used to lock two members of the planetary gear unit together. Let's take a look at how this clutch operates. In the next two frames are shown cross-section diagrams explaining the action of the clutch as it is applied and then released.

Study the illustration shown below and note the interaction between the clutch plates, piston, and release springs as you read the action described below the illustration.


RELEASE SPRING COMPRESSED
CLUTCH PLATES FIXED TO PLANET CARRIER
HYDRAULIC PRESSURE APPLIED TO PISTON
CLUTCH PLATES FIXED TO SUN GEAR
INPUT SHAFT
PISTON

1. Hydraulic pressure forces the piston to move, compressing the release springs and pressing the clutch plates together.

2. With the clutch plates pressed together, the planet carrier and sun gear are now locked together. Remember, the clutch plates are indirectly affixed to the members.

3. Now, as you know, two members locked together provide direct drive.

NO RESPONSE REQUIRED

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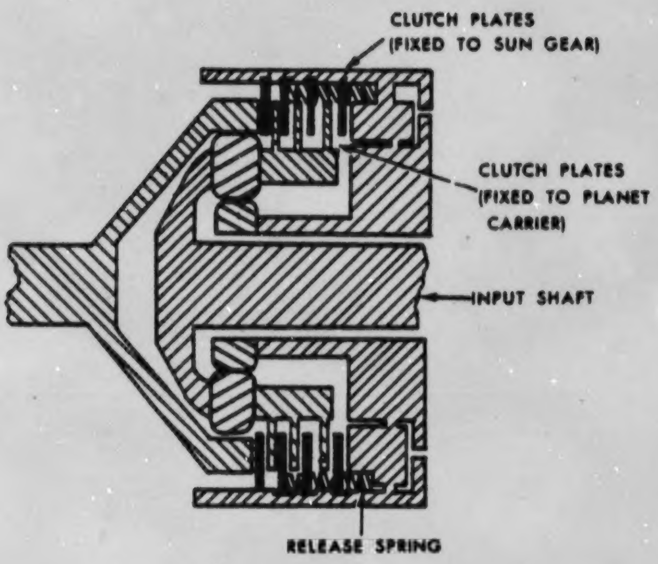
Study the diagram below carefully as you read the action described below the illustration.


CLUTCH PLATES (FIXED TO SUN GEAR)
CLUTCH PLATES (FIXED TO PLANET CARRIER)
INPUT SHAFT
RELEASE SPRING

1. When hydraulic pressure is removed from the piston, the release springs force the piston back, allowing the clutch plates to separate.

2. With the clutch plates separated, the clutch is released and the members of the planetary gear unit are allowed to turn independently.

QUESTION 16

Fill in the blank space with the correct term.

a. The multiple-disc clutch is applied by ___________ pressure.

b. The multiple-disc clutch is released by ___________ pressure.

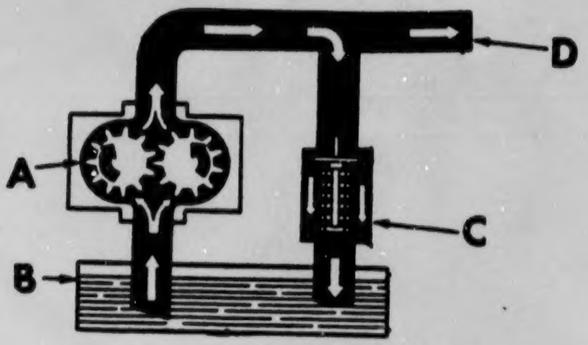
ANSWERS TO QUESTION 16

a. hydraulic
b. spring

Frame 20

In automatic transmissions, fluid is pressurized and sent to all parts of the unit to achieve automatic operation.

The hydraulic pressure is supplied and controlled by the units of the basic oil pressure system, as shown in the illustration below.



A The pump - is driven whenever the engine runs. Its function is to supply pressure for the transmission fluid.

B The pan - acts as a reservoir for the fluid required by the transmission.

C The pressure regulator valve - its function is to control hydraulic pressure supplied by the pump. A spring holds the valve closed until hydraulic pressure becomes greater than the spring pressure. Valve opening allows the excess hydraulic pressure to return to the pan.

D Path of the controlled hydraulic pressure to the various parts of the transmission.

QUESTION 17

Fill in the blank spaces with the correct terms.

a. The ____________ supplies transmission oil pressure.

b. The oil pump is ____________ driven.

c. The ____________ ____________ controls pump output.

ANSWERS TO QUESTION 17

a. pump
b. engine
c. pressure regulator

Frame 21

Automatic transmissions shift automatically but when they shift is partially determined by the operator of the vehicle and the manner in which he drives.

When the gear selector (gear shift lever) of a vehicle equipped with an automatic two-speed transmission is placed in DRIVE position and the accelerator is depressed, the vehicle moves forward. As it gains speed the transmission will automatically shift to HIGH gear. When the accelerator is let up and the vehicle is allowed to slow down to a low speed, the transmission will automatically shift down to LOW gear.

The automatic shifting of the transmission is controlled by variable hydraulic pressures (throttle pressure and governor pressure) which are determined by the position of the accelerator and the speed of the vehicle.

These two variable pressures (throttle and governor) act upon a valve (shifter valve) within the transmission that controls pressure to the servo and clutch. The throttle pressure delays the upshift while the governor pressure causes the upshift.

The following frames will show you how these pressures cause an automatic transmission to shift.

NO RESPONSE REQUIRED

Frame 22

The following six components of a simple two-speed hydraulic control system control the constant and variable pressures in the automatic transmission.

1. Pump.

   a. Purpose - supply hydraulic pressure.

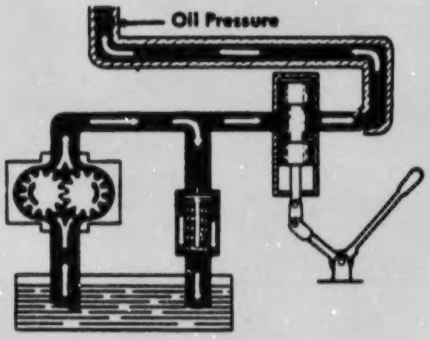
   b. Front pump - is driven by the engine.

   c. Rear pump - is driven by the output shaft. Its purpose is to provide hydraulic pressure for a push start.

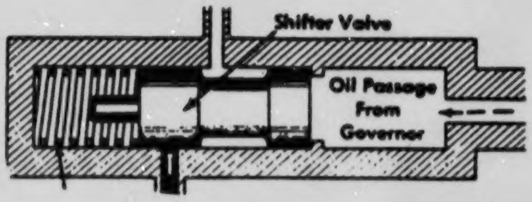
Note: All automatic transmissions don't have a rear pump.

2. Pressure regulator valve - controls the hydraulic pressure produced by the front and rear pump.

3. Manual valve - hand operated - controlled by the shift lever - is used to select the range of operation - turns mainline pressure on and off.



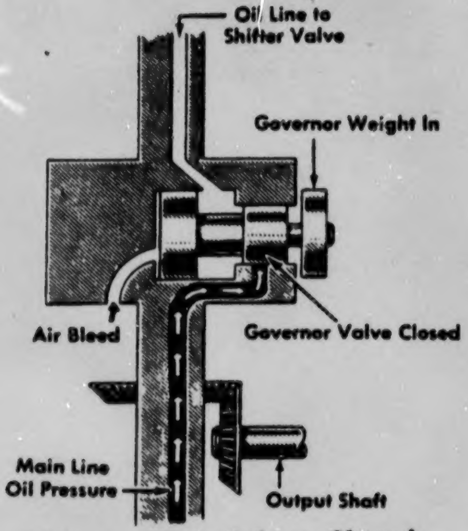
4. Shifter valve - a shifter valve is used to automatically shift from low to direct drive. The valve is opened hydraulically when the oil pressure on the end of the valve is greater than the spring pressure.



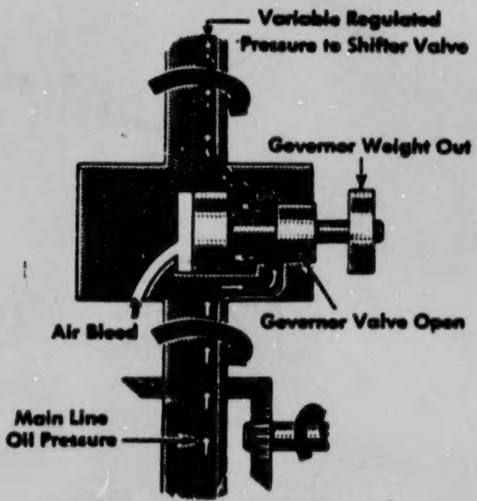
5. Governor valve - causes upshift. How it works:

   a. Driven by the output shaft - amount of pressure determined by speed of the vehicle (output shaft).

   b. Works on one end of shifter valve and when it becomes greater than throttle pressure moves the shifter valve so as to cause the upshift.


Oil Line to Shifter Valve
Governor Weight In
Air Bleed
Governor Valve Closed
Main Line Oil Pressure
Output Shaft

Governor With Valves Closed.

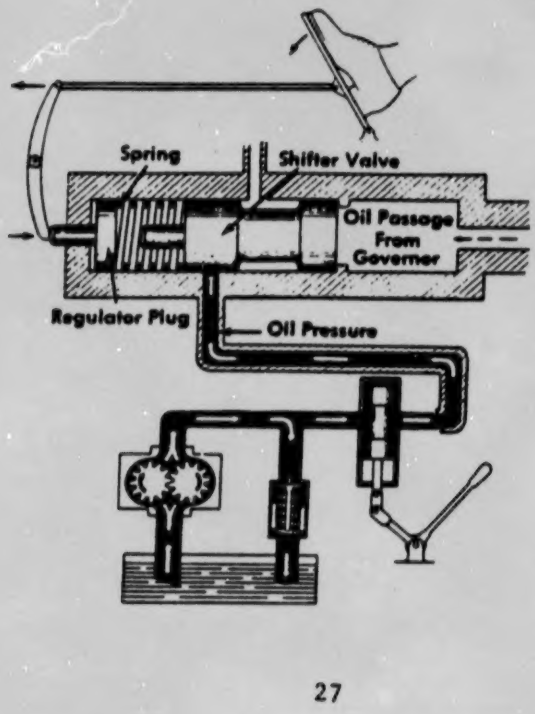

Variable Regulated Pressure to Shifter Valve
Governor Weight Out
Air Bleed
Governor Valve Open
Main Line Oil Pressure

Governor With Valve Opened.

6. Throttle valve - delays the upshift. How it works:

a. Amount of throttle pressure is determined by this valve which is controlled manually by the position of the accelerator.

b. Delays the upshift or keeps the vehicle in LOW gear by sending pressure to the opposite end of the shifter valve from governor pressure holding the shifter valve closed, depending on how hard you press the accelerator pedal. The throttle valve is aided by the shifter valve spring.


Spring
Shifter Valve
Oil Passage From Governor
Regulator Plug
Oil Pressure

QUESTION 18

a. ____________ supplies pressure to operate transmission.

b. ____________ controls hydraulic pressure.

c. ____________ is used to select the range.

d. ____________ automatically shifts from low to direct drive.

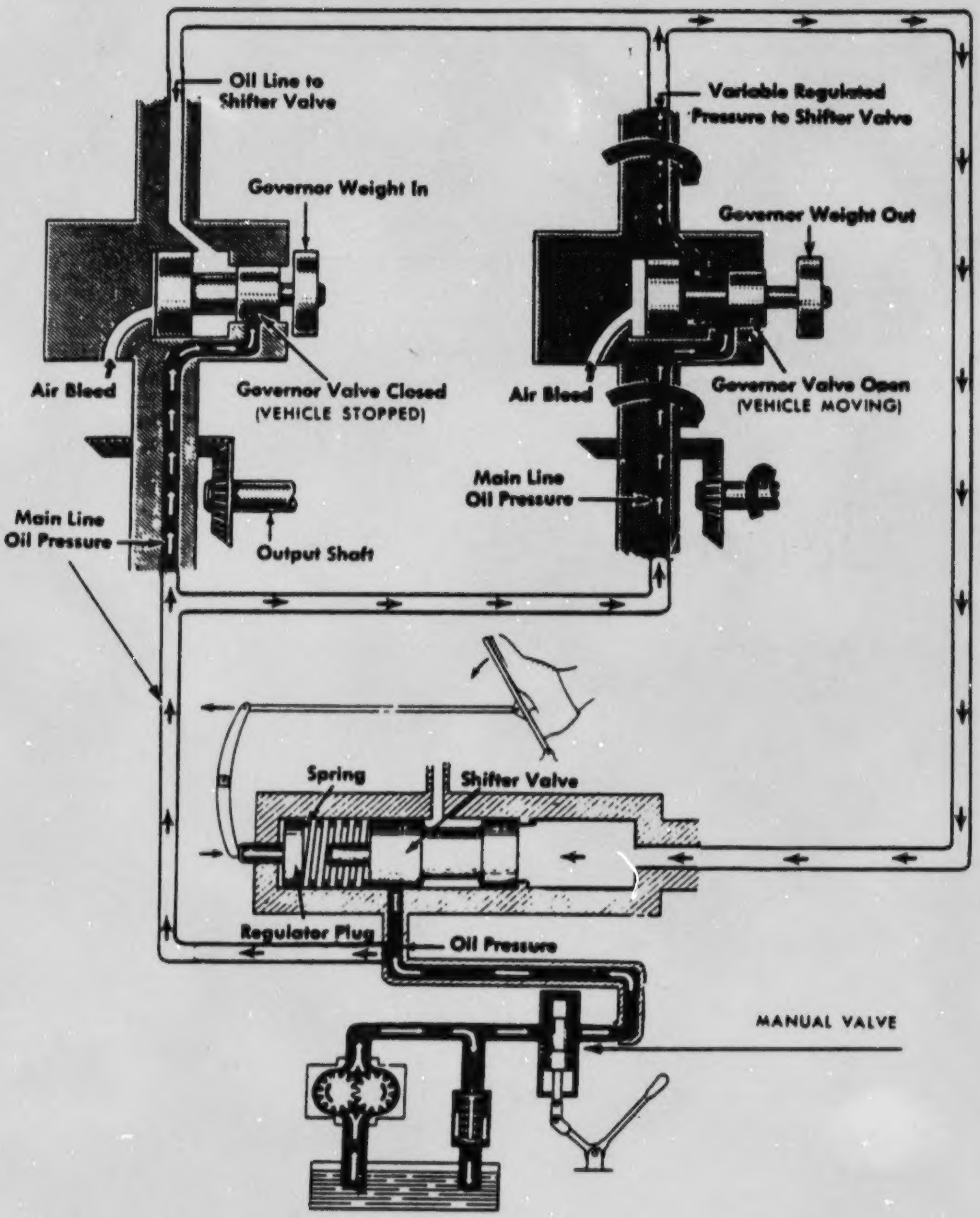
e. ____________ causes upshift.

f. ____________ delays upshift.

ANSWERS TO QUESTION 18

a. pump
b. pressure regulator valve
c. manual valve
d. shifter valve
e. governor valve
f. throttle valve

Frame 23

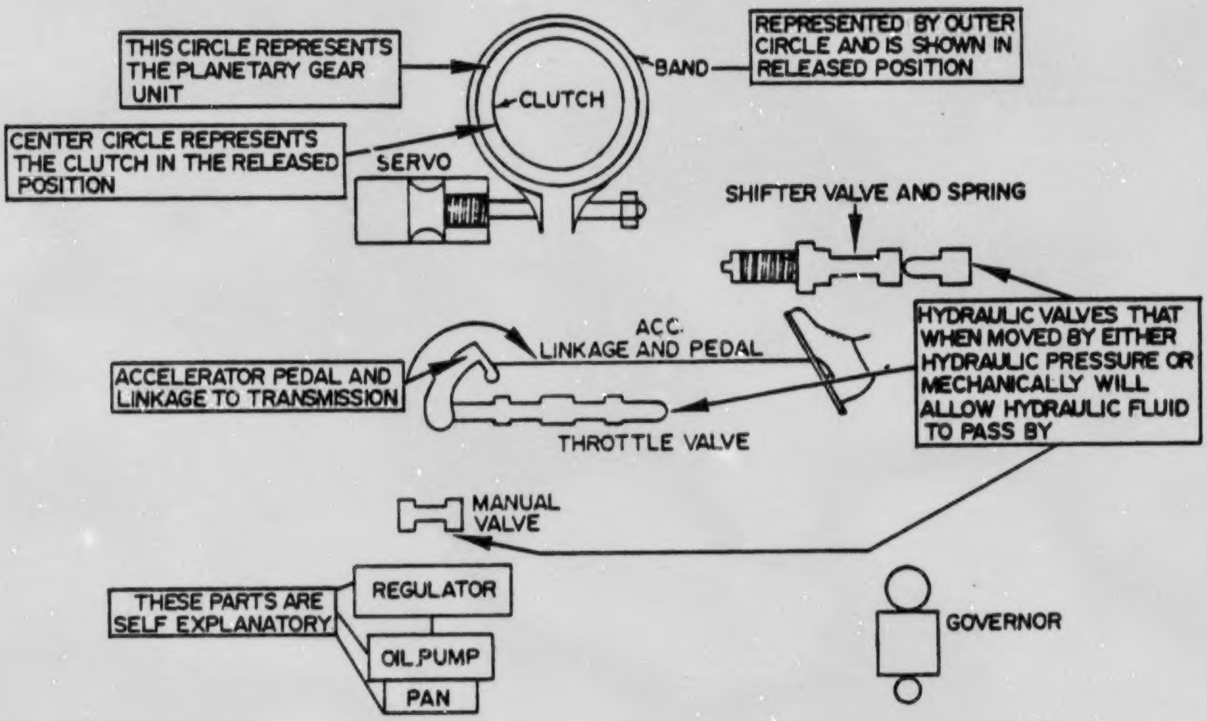

Oil Line to Shifter Valve
Governor Weight In
Air Bleed
Governor Valve Closed (VEHICLE STOPPED)
Main Line Oil Pressure
Output Shaft
Variable Regulated Pressure to Shifter Valve
Governor Weight Out
Air Bleed
Governor Valve Open (VEHICLE MOVING)
Main Line Oil Pressure
Spring
Shifter Valve
Regulator Plug
Oil Pressure
MANUAL VALVE

NO RESPONSE REQUIRED

Frame 24

Before going into the actual opertion of the two-speed automatic transmission, you must become familiar with a diagram that will be used to illustrate and explain the function of the basic parts of the transmission. This diagram will be used only to illustrate the action of these parts and the flow of hydraulic fluid as the transmission goes through its automatic operation.

This diagram is simplified and does not illustrate the parts in their true form. As you study this diagram, think of the parts you already have knowledge of from previous parts of the lesson.


THIS CIRCLE REPRESENTS THE PLANETARY GEAR UNIT
CLUTCH
BAND
REPRESENTED BY OUTER CIRCLE AND IS SHOWN IN RELEASED POSITION
CENTER CIRCLE REPRESENTS THE CLUTCH IN THE RELEASED POSITION
SERVO
SHIFTER VALVE AND SPRING
ACC. LINKAGE AND PEDAL
ACCELERATOR PEDAL AND LINKAGE TO TRANSMISSION
THROTTLE VALVE
HYDRAULIC VALVES THAT WHEN MOVED BY EITHER HYDRAULIC PRESSURE OR MECHANICALLY WILL ALLOW HYDRAULIC FLUID TO PASS BY
MANUAL VALVE
THESE PARTS ARE SELF EXPLANATORY
REGULATOR
OIL PUMP
PAN
GOVERNOR

QUESTION 19

Fill in the blank spaces below.

a. Which valve is positioned with the selector?

b. What operates the throttle valve?

a. ______________________________

b. ______________________________

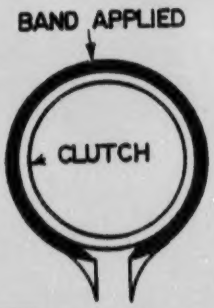
ANSWERS TO QUESTION 19

a. manual valve
b. accelerator pedal

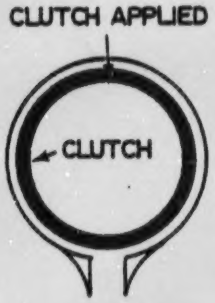
Frame 25

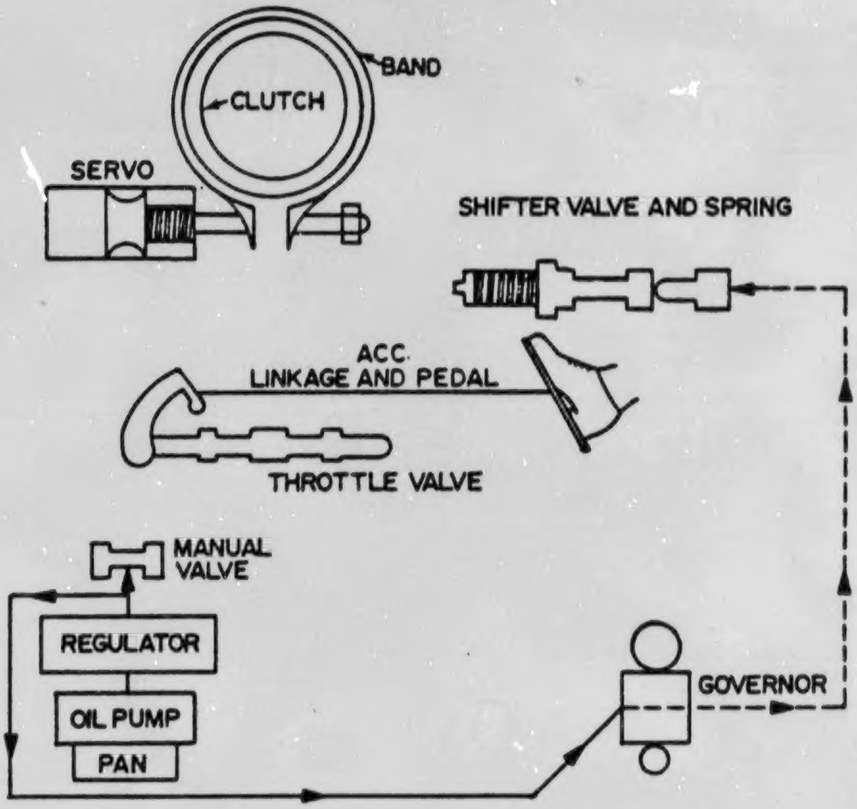
To better explain the clutch and band illustration, they are shown in operation below.

Shaded area indicates the band has been applied holding a member of the planetary gear unit.


BAND APPLIED
CLUTCH

Shaded area now indicates the clutch has been applied, (see the difference) locking two members of the planetary gear unit together.


CLUTCH APPLIED
CLUTCH


BAND
CLUTCH
SERVO
SHIFTER VALVE AND SPRING
ACC.
LINKAGE AND PEDAL
THROTTLE VALVE
MANUAL VALVE
REGULATOR
OIL PUMP
PAN
GOVERNOR

The flow of hydraulic fluid under pressure in all the following diagrams will be indicated as it appears in the above illustration and as described below.

Mainline pressure - is the pressure that is controlled only by the pressure regulator valve. Mainline pressure is represented by a solid black line. (See line from pressure regulator to governor.)

Variable pressure - is pressure that is varied in amount by the opening of various valves. Variable pressure is represented by a broken black line. (See line from governor to shifter valve.)

NO RESPONSE REQUIRED

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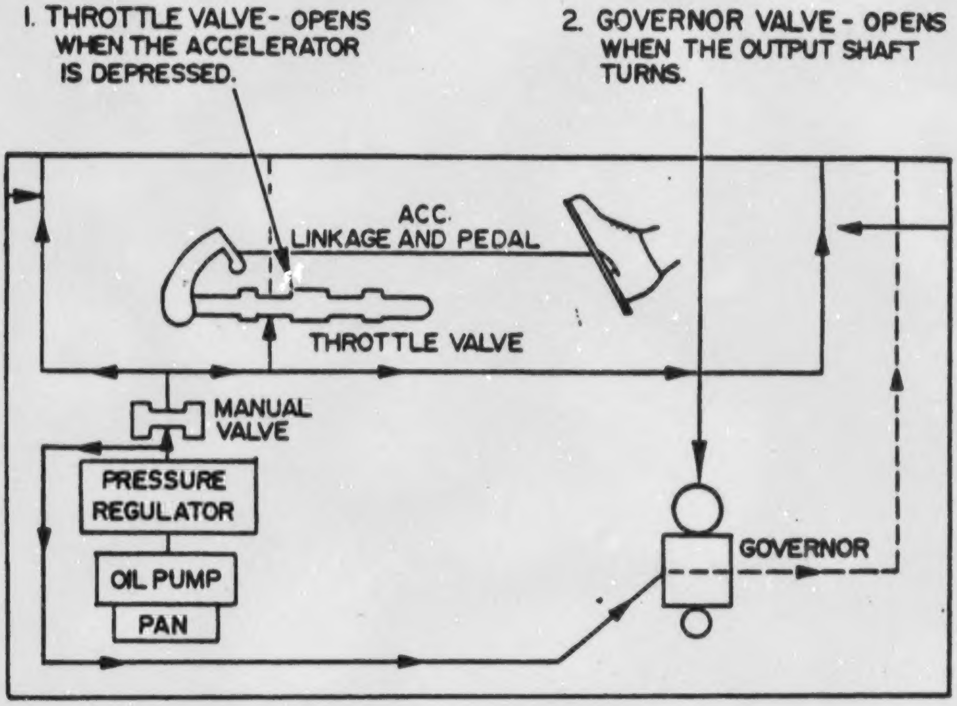
Frame 26

When the accelerator is depressed and the vehicle begins to move in LOW gear, two valves begin to open. The two valves that open are:


1. THROTTLE VALVE - OPENS WHEN THE ACCELERATOR IS DEPRESSED.
2. GOVERNOR VALVE - OPENS WHEN THE OUTPUT SHAFT TURNS.
ACC. LINKAGE AND PEDAL
THROTTLE VALVE
MANUAL VALVE
PRESSURE REGULATOR
OIL PUMP
PAN
GOVERNOR

When the throttle valve and governor valve open, they allow mainline pressure, previously blocked, to meter through. In other words, the degree to which the valves open determines the amount of pressure allowed to pass through them. When this metered pressure (illustrated as broken lines on the diagram) passes through these valves it is no longer mainline pressure. It is now called throttle pressure and governor pressure. That pressure coming through the throttle valve is called "throttle pressure," and the pressure passing through the governor valve is called "governor pressure."

QUESTION 20

a. When does the throttle valve open? ______________________________

b. When does the governor valve open? ______________________________

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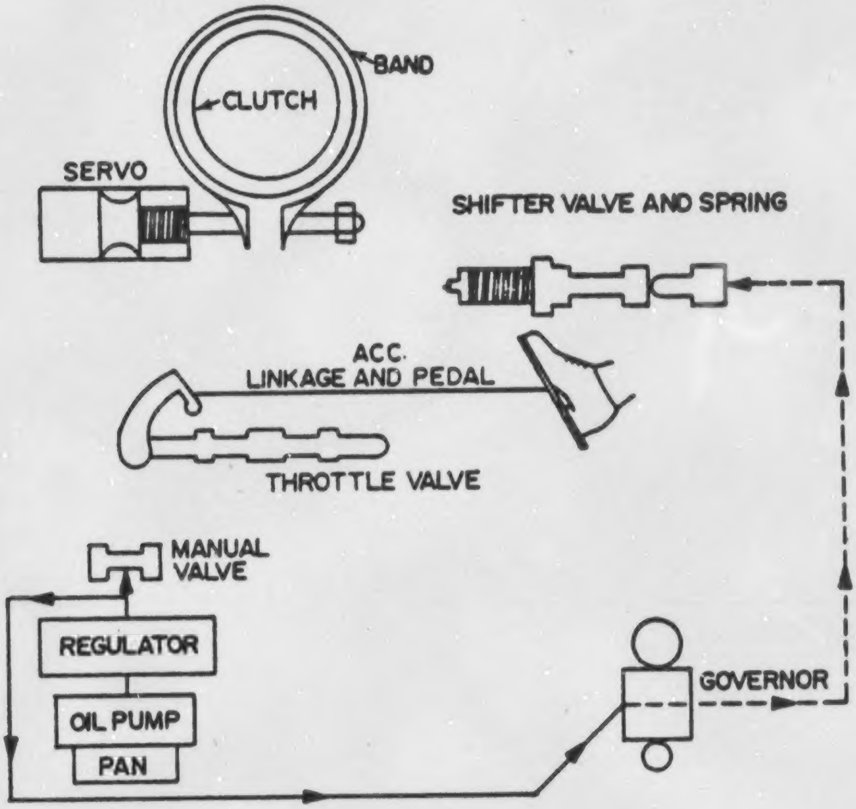
ANSWERS TO QUESTION 20

a. When the accelerator is depressed.

b. When the output shaft turns.

Frame 27

Shade in the pressure regulator, oil pump, and pan in red. Trace the line from the manual valve to the governor in red. This shows where mainline pressure goes when the vehicle is in neutral and the engine is running. The vehicle is in neutral because neither the band nor clutch are applied.


BAND
CLUTCH
SERVO
SHIFTER VALVE AND SPRING
ACC.
LINKAGE AND PEDAL
THROTTLE VALVE
MANUAL
VALVE
REGULATOR
OIL PUMP
PAN
GOVERNOR

QUESTION 21

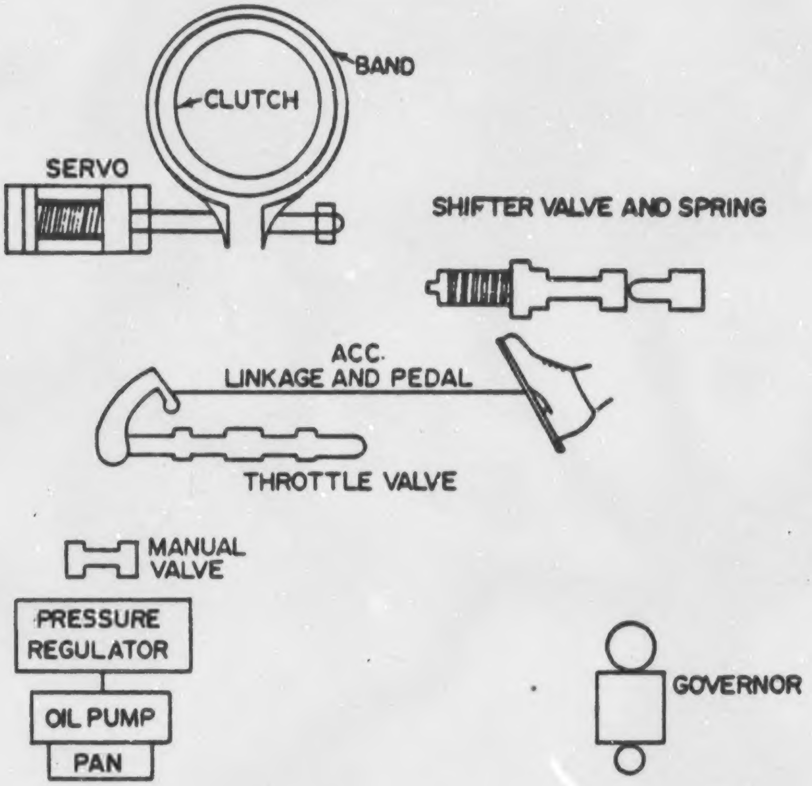
In what position is the manual valve when neither the band nor the clutch is applied?

ANSWER TO QUESTION 21

Neutral

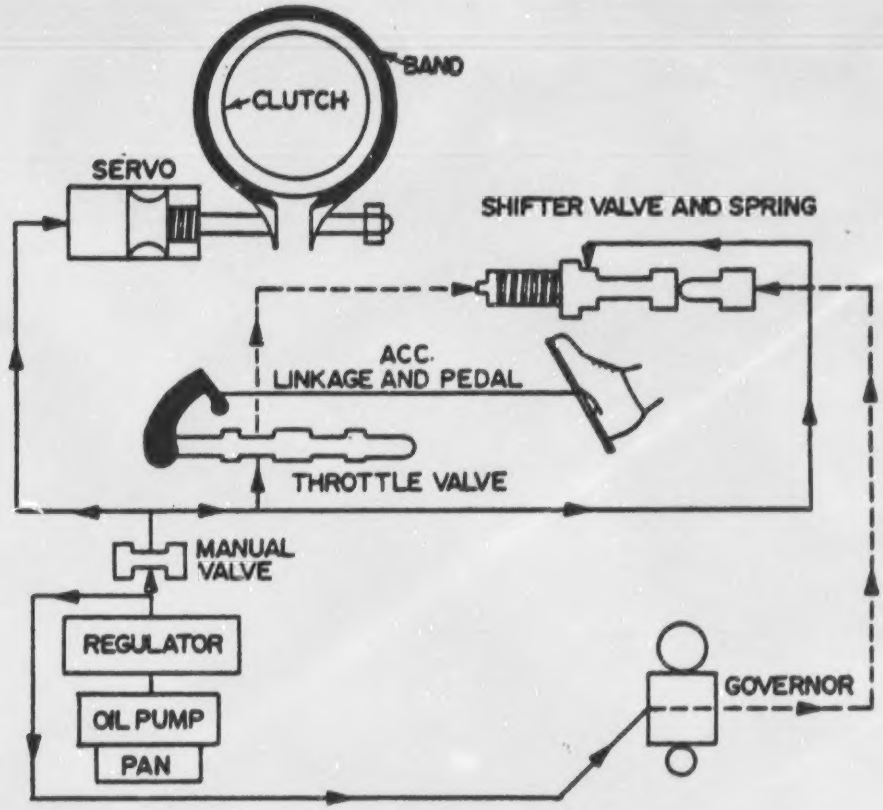
Frame 28

In the diagram below, the vehicle is in neutral and the engine is running. Draw in red the line or lines to show where mainline pressure goes.


BAND
CLUTCH
SERVO
SHIFTER VALVE AND SPRING
ACC.
LINKAGE AND PEDAL
THROTTLE VALVE
MANUAL VALVE
PRESSURE REGULATOR
OIL PUMP
PAN
GOVERNOR

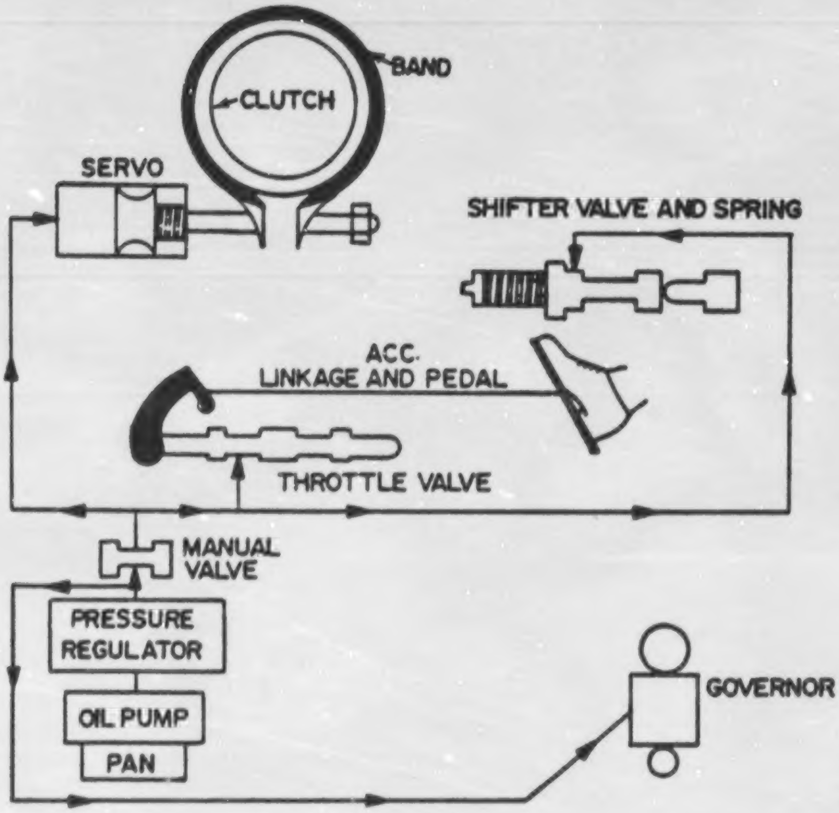
The shift lever has been placed in DRIVE position. This opened the manual valve, allowing mainline pressure to go to the servo and apply the band, which put the vehicle into LOW gear. Mainline pressure went also to the throttle valve and to the shifter valve. The accelerator is depressed, so we have throttle pressure going to one end of the shifter valve, holding it closed. The vehicle is moving, turning the output shaft so we have governor pressure going to one end of the shifter valve. The vehicle will stay in LOW gear until governor pressure becomes greater than the shifter valve spring and throttle pressure combined.

Trace in red all lines showing where mainline pressure goes with the vehicle moving in LOW gear. Trace throttle pressure in green and governor pressure in blue.


BAND
CLUTCH
SERVO
SHIFTER VALVE AND SPRING
ACC.
LINKAGE AND PEDAL
THROTTLE VALVE
MANUAL
VALVE
REGULATOR
OIL PUMP
PAN
GOVERNOR

44

In the diagram below, the vehicle is moving in LOW gear. Draw in green to show where throttle pressure goes, and draw in blue to show where governor pressure goes.


BAND
CLUTCH
SERVO
SHIFTER VALVE AND SPRING
ACC.
LINKAGE AND PEDAL
THROTTLE VALVE
MANUAL
VALVE
PRESSURE
REGULATOR
OIL PUMP
PAN
GOVERNOR

QUESTION 22

Where does the throttle pressure go?

521

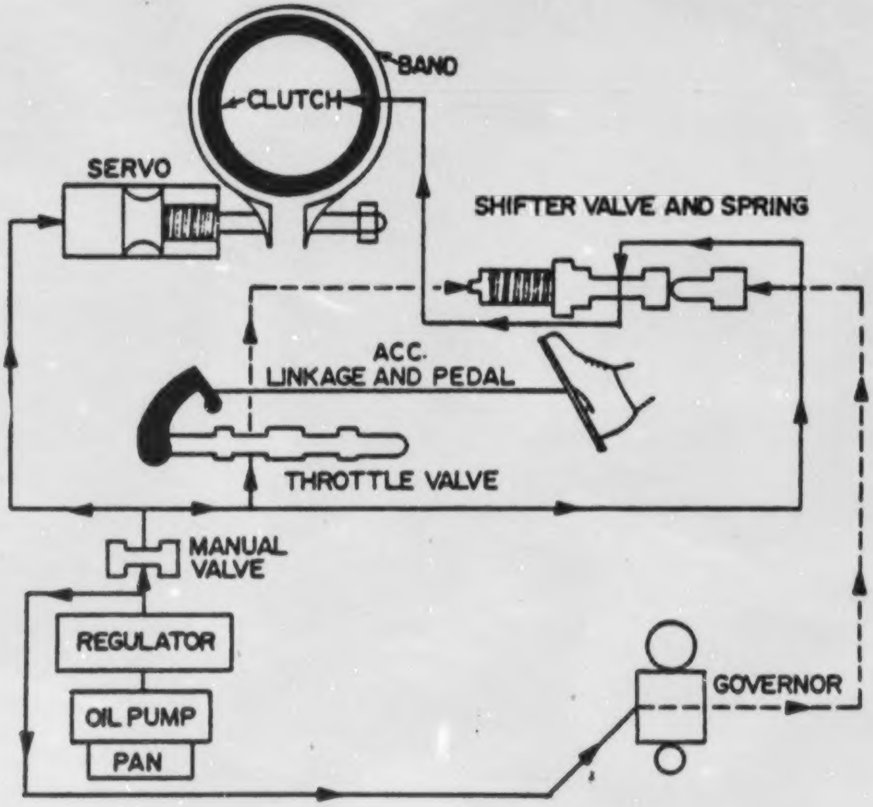
ANSWER TO QUESTION 22

To the spring loaded side of the shifter valve.

Frame 31

The diagram below shows the vehicle moving in HIGH gear. Governor pressure has become greater than throttle pressure and moved the shifter valve. This action allowed mainline pressure, which was blocked by the shifter valve, to pass through and release the band and apply the clutch at the same time, putting the vehicle into HIGH gear. Look at the servo in the diagram. There is mainline pressure on both sides of the piston. When the shifter valve opened, mainline pressure went to the release side of the servo. This caused equal pressure on both sides of the servo piston, allowing the servo spring to expand and release the band. Trace in red all lines showing where mainline pressure goes with the vehicle moving in HIGH gear. Trace throttle pressure in green and governor pressure in blue.

VEHICLE MOVING IN HIGH GEAR


BAND
CLUTCH
SERVO
SHIFTER VALVE AND SPRING
ACC.
LINKAGE AND PEDAL
THROTTLE VALVE
MANUAL VALVE
REGULATOR
OIL PUMP
PAN
GOVERNOR

QUESTION 23

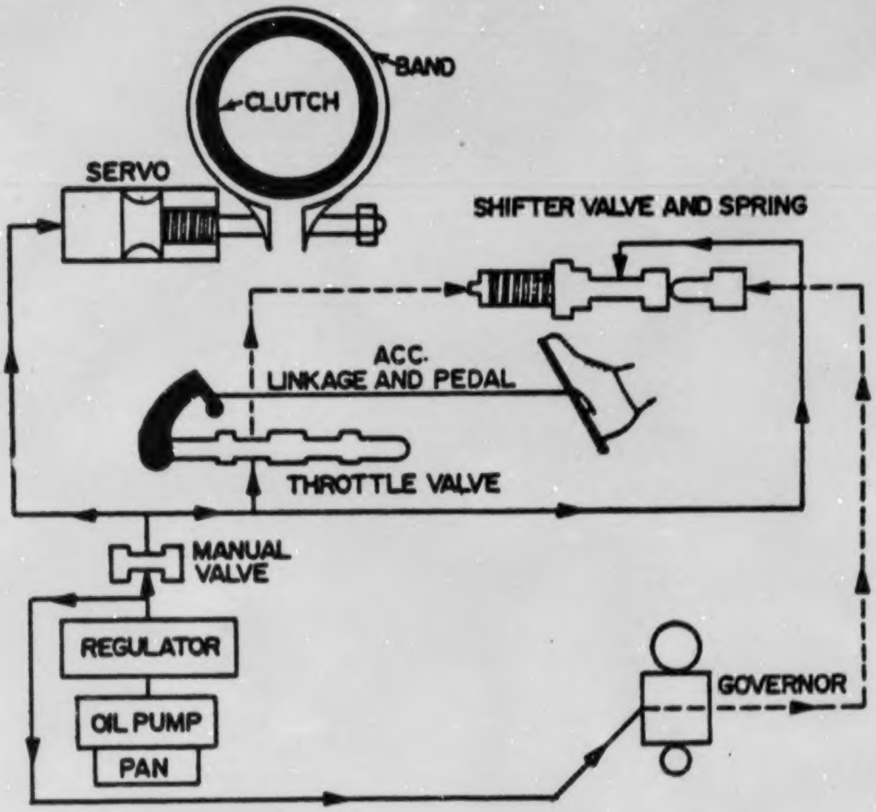
What moves the shifter valve to change from low to high gear?

ANSWER TO QUESTION 23

Governor pressure

Frame 32

In the diagram below, draw in red the mainline pressure to show how the vehicle shifted from LOW to HIGH gear. Draw throttle pressure in green and governor pressure in blue.


BAND
CLUTCH
SERVO
SHIFTER VALVE AND SPRING
ACC. LINKAGE AND PEDAL
THROTTLE VALVE
MANUAL VALVE
REGULATOR
OIL PUMP
PAN
GOVERNOR

QUESTION 24

a. What pressure caused the upshift?

b. What pressure delayed the upshift?

ANSWERS TO QUESTION 24

a. Governor pressure.
b. Throttle pressure.

Frame 33

Drive units are used in automatic transmission-equipped vehicles to connect the engine and transmission. The drive unit, which is bolted on to the engine, utilizes hydraulic pressure in its operation and it takes the place of the clutch used with standard transmissions.

There are many different automatic transmissions, but only two types of drive units. The TYPE of transmission determines which of the two drive units is used.

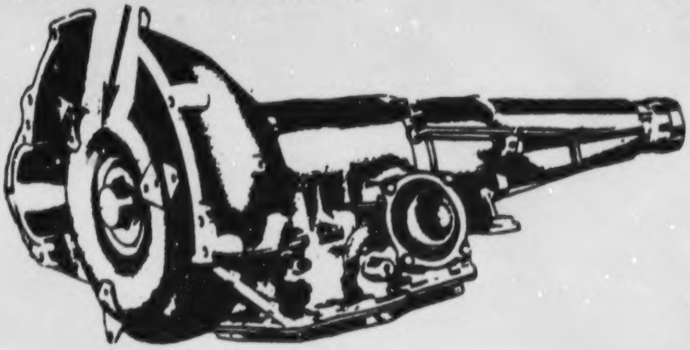
The next portion of this lesson will explain the construction and operation of these two drive units.

The drive unit is bolted to the engine and is connected to the oil pump. Therefore, the drive unit drives the oil pump whenever the engine is running.

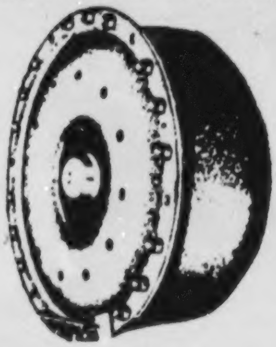
The output of the basic oil pressure system pump causes the drive unit of an automatic transmission to be pressure-filled.

The two drive units are shown in the illustration below.

TORQUE CONVERTER
(INSTALLED IN TRANSMISSION)



FLUID COUPLING
(REMOVED FROM THE TRANSMISSION)



As you will note from the illustrations above, the drive units are similar in outward appearance, but the internal construction and the operation are quite different.

QUESTION 25

a. The mechanisms which take the place of the clutch used with standard transmissions are called ____________ units.

b. The two types of drive units are the ____________ ____________ and the ____________ ____________.

c. The type of ____________ determines which drive unit will be used.

ANSWERS TO QUESTION 25

a. drive
b. torque converter, fluid coupling
c. transmission

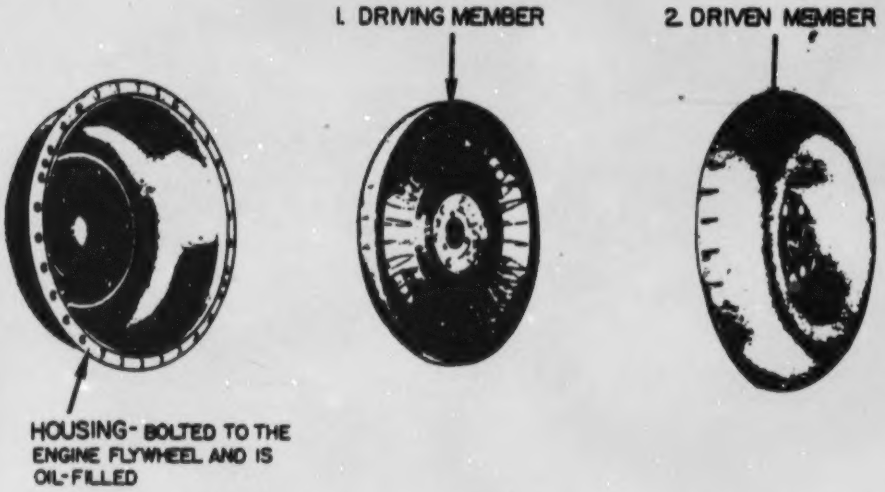
FRAME 34

You have found that there are two types of drive units used with automatic transmissions. You have also learned that both drive units are similar in outward appearance but that the internal construction and operation are quite different.

The torque converter is used in all but one transmission.

The fluid coupling is used with the hydramatic transmission only. The reason for this is simply because of the gear arrangements within the hydramatic transmission.

The fluid coupling has only two (2) members or parts, which are shown separated in the illustration below.



This is an outside view of the driven member. Inside it looks just like the driving member.

Vanes (blades) on the inside of the members of the fluid coupling are not curved. They may be compared to the segments of a split grapefruit.

QUESTION 26

a. What is the name of the transmission that uses a fluid coupling as a drive unit?

b. Name the two members of the fluid coupling.

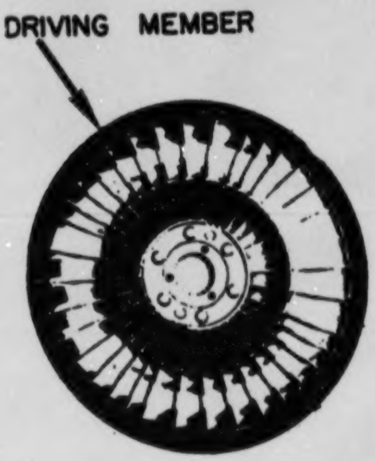
c. What is the shape of the vanes (blades) inside the members of the fluid coupling?

ANSWERS TO QUESTION 26

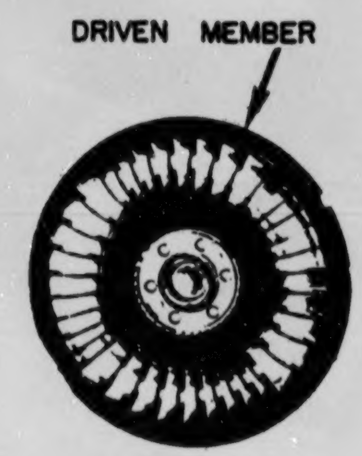
a. Hydramatic
b. Driving and driven
c. They are straight

Frame 35

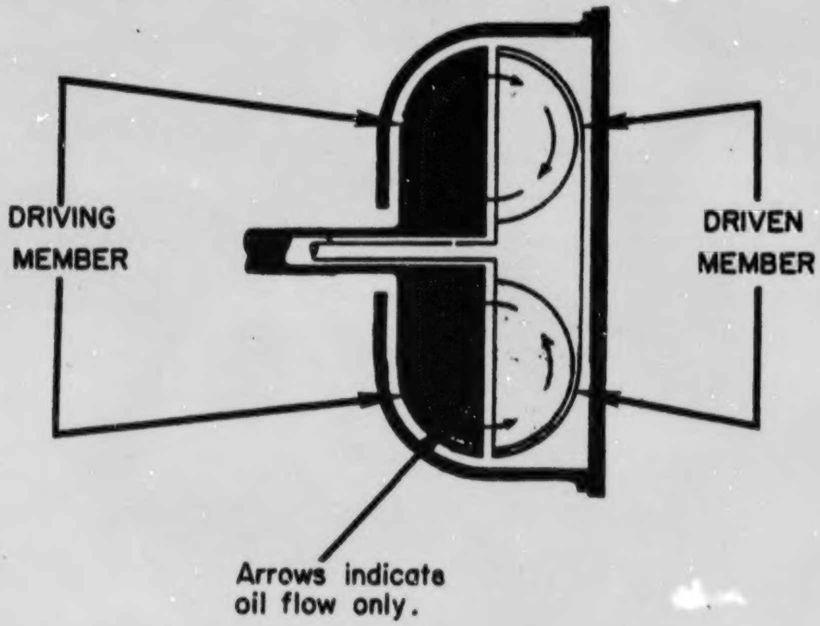
The fluid coupling, through the action of its members, must do for the HYDRAMATIC transmission what the clutch does for the standard transmission. The driving member drives the driven member through the use of oil. The driven member, in turn, drives the transmission mainshaft.


DRIVING MEMBER

Look alike
on the
inside,
don't they?


DRIVEN MEMBER

The illustration below shows a cross-sectional diagram of a fluid coupling with the members assembled in the oil-filled housing.


DRIVING MEMBER
DRIVEN MEMBER
Arrows indicate oil flow only.

QUESTION 27

a. What is the drawing member used for?

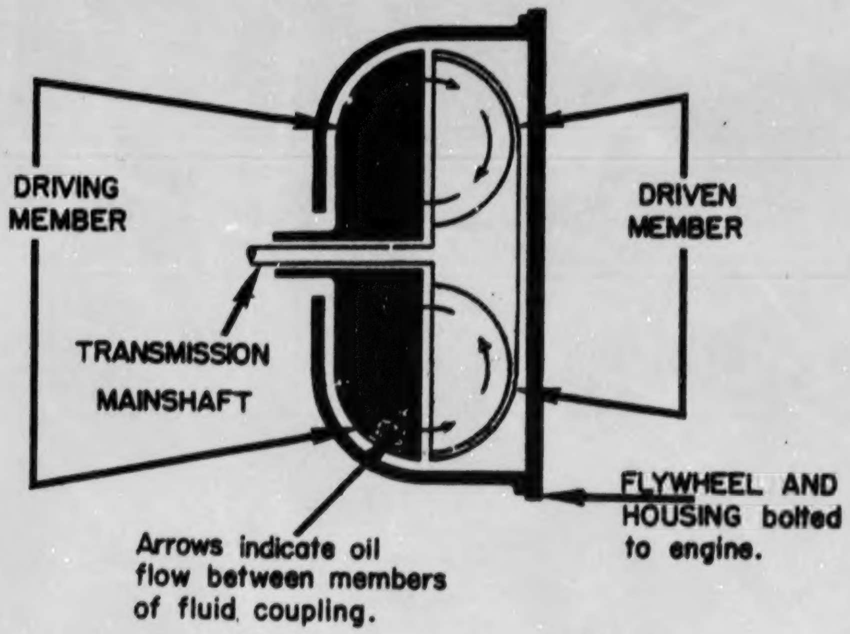
b. What is the driven member used for?

ANSWERS TO QUESTION 27

a. To drive the driven member through the use of oil.
b. To drive the transmission mainshaft.

Frame 36

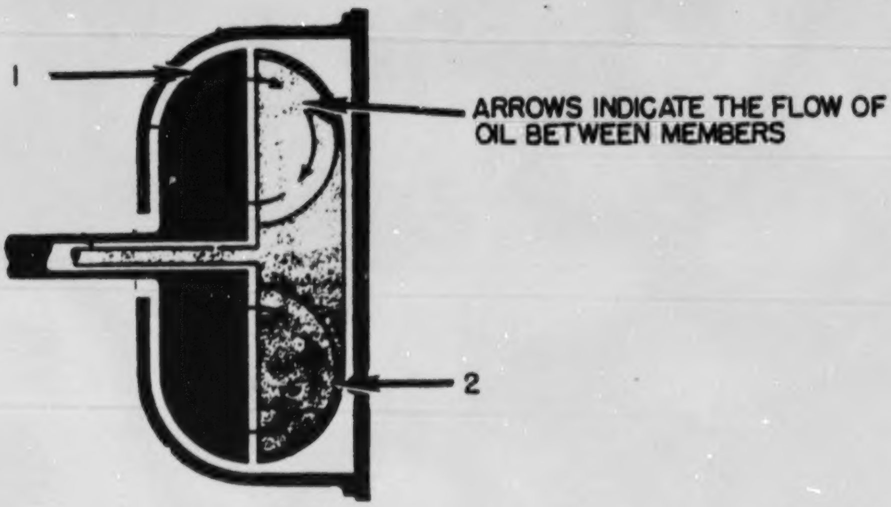
CUTAWAY CROSS SECTION
OF FLUID COUPLING


DRIVING MEMBER
DRIVEN MEMBER
TRANSMISSION MAINSHAFT
FLYWHEEL AND HOUSING bolted to engine.
Arrows indicate oil flow between members of fluid coupling.

Using the illustration above, let's study the action of the members of the fluid coupling. With the engine running and the transmission in gear, the driving member turns. Vanes on the driving member pick up oil in the oil-filled housing. Centrifugal force, created by the turning of the driving member, forces oil out and away from the driving member. The oil hits vanes of the driven member, causing it to turn. As was mentioned previously, the driven member drives the transmission mainshaft and the fluid coupling is now connecting the engine and transmission, much as the clutch connects the standard transmission.

NO RESPONSE REQUIRED

The fluid coupling of the HYDRAMATIC transmission must act as a clutch just as the torque converter does for all other automatic transmissions. The operation of the two drive units is very similar in the way that the connection is made between an engine that is running and a transmission that is in gear.



Let us study the operation of the fluid coupling with the vehicle stopped, the engine running, and the transmission in gear. The driving member (#1) turns slowly, due to engine idling when the vehicle is stopped. Oil is thrown from the driving member with very limited force as it hits the driven member. This oil from the driving member is not forceful enough to turn the driven member which is connected to the mainshaft. Of course, then, the transmission mainshaft will not turn either. The transmission is now disconnected from the engine and the fluid coupling is acting like a clutch.

The fluid coupling, in addition to acting as a clutch, has one other function. This function is to transmit torque from the engine to the transmission through the use of oil.

QUESTION 28

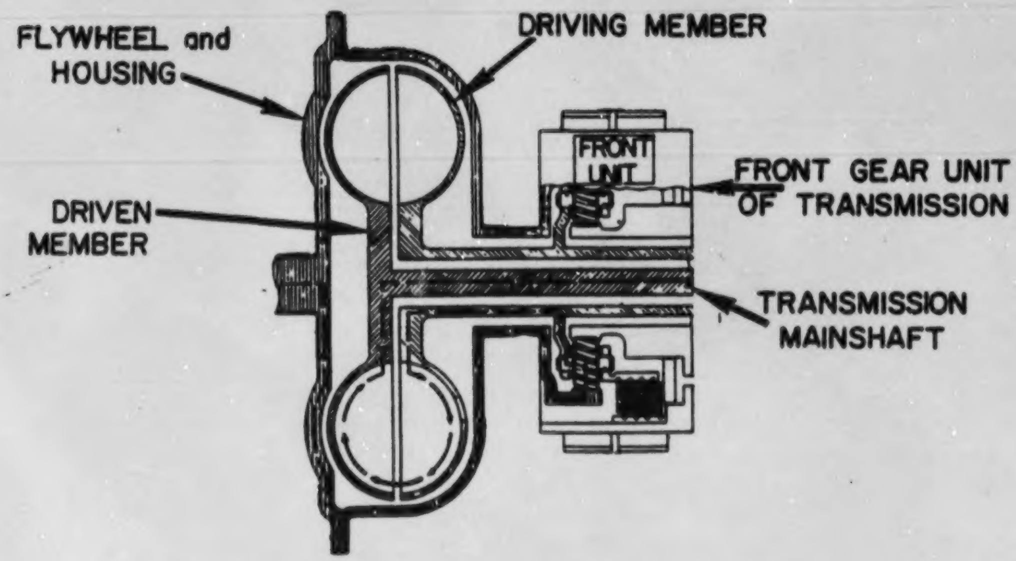
What are the two purposes of a fluid coupling?

ANSWERS TO QUESTION 28

a. Act as a clutch.
b. Transmit power.

Frame 38

TORQUE TRANSMITTED BY A FLUID COUPLING
(Arrows indicate flow of power through unit)



Just how does the fluid coupling transmit torque? With the transmission in gear and the accelerator depressed, the following events take place. First, the driving member turns at an increased speed, picking up oil which is thrown against the driven member with great force. This driven member turns and drives the transmission main shaft. Since the main shaft is connected to gears in the transmission, when the main shaft turns, the vehicle moves. In this manner, the fluid coupling transmits torque from the engine to the transmission.

To assist you in acquiring a better understanding of power flow, follow the small arrows starting at point "A" in the diagram above as you read the following steps:

1. Power from the engine is transmitted by the flywheel and housing to the front gear unit.

2. Power from the front gear unit is transmitted to the driving member of the fluid coupling.

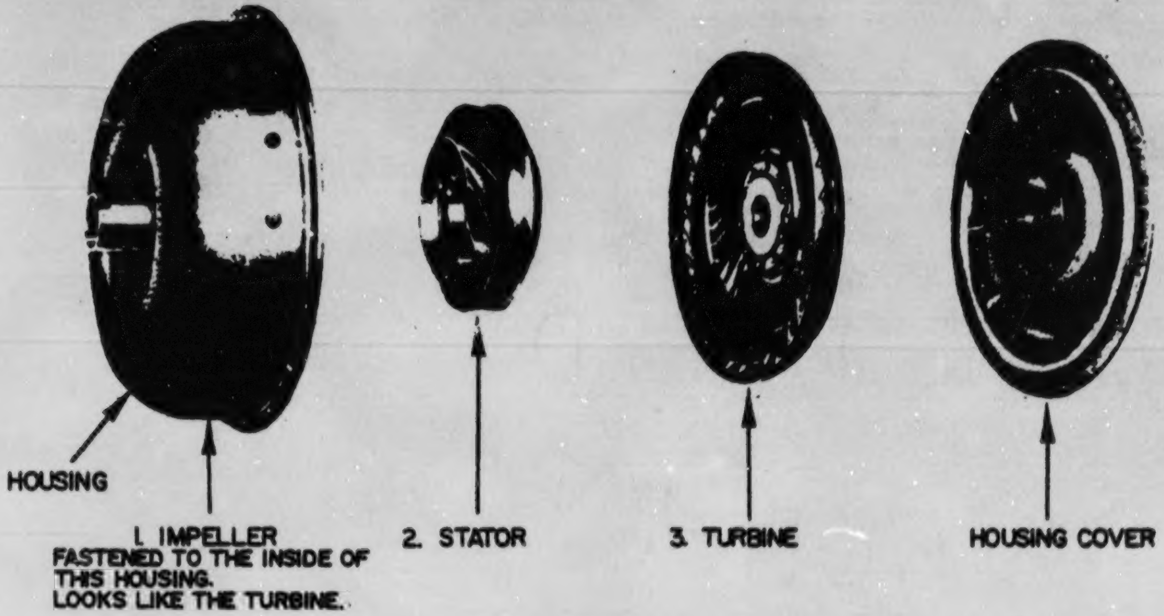
3. Power from the driving member is transmitted to the driven member through oil.

4. Power is transmitted from the driven member to the main shaft and from there to the rear wheels.

NO RESPONSE REQUIRED

500

The torque converter is used in all automatic transmissions except one. The torque converter has three (3) members. These members (parts) are shown below.


HOUSING
1. IMPELLER
FASTENED TO THE INSIDE OF
THIS HOUSING.
LOOKS LIKE THE TURBINE.
2. STATOR
3. TURBINE
HOUSING COVER

Note: The stator and turbine have curved blades. The blades are curved to change direction of flow of the oil in the torque converter, much the same as the blades of a fan are used to direct the flow of air.

QUESTION 29

a. Why are the blades of the stator and turbine curved?

b. How many transmissions use the torque converter?

530

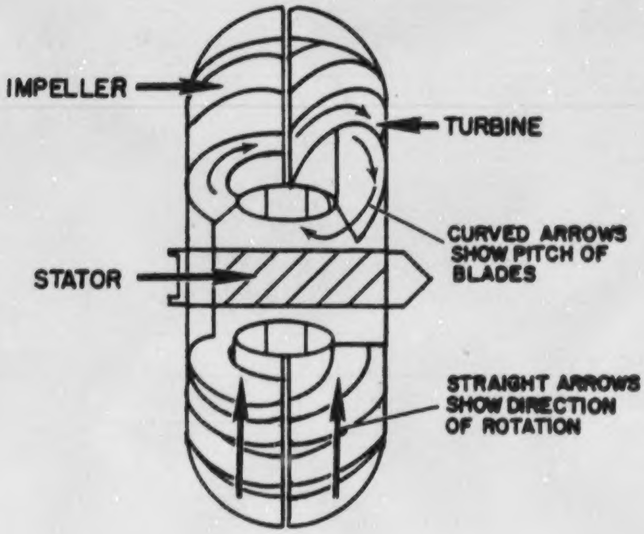
508

ANSWERS TO QUESTION 29

a. The blades are curved to change the direction of flow of oil in the torque converter.
b. All transmissions except one.

Frame 40

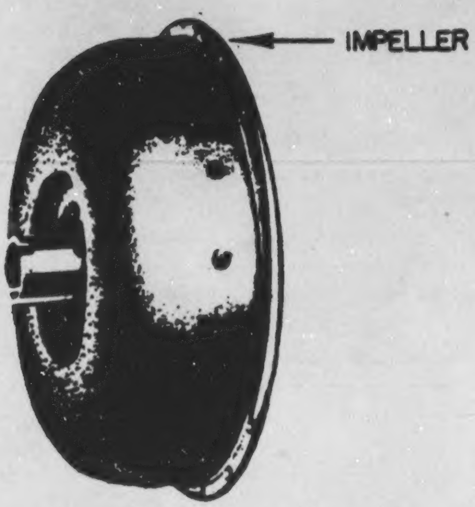
A cutaway diagram of the torque converter members assembled within the housing is shown in the illustration below. This housing is oil-filled.


IMPELLER
TURBINE
CURVED ARROWS SHOW PITCH OF BLADES
STATOR
STRAIGHT ARROWS SHOW DIRECTION OF ROTATION

NO RESPONSE REQUIRED

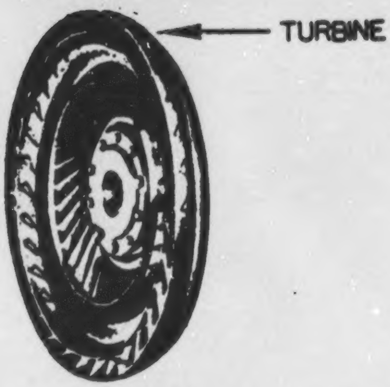
531

Frame 41



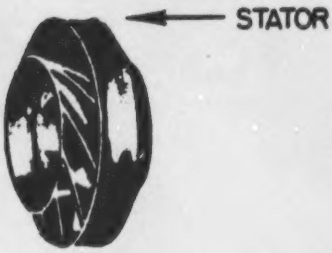
Impeller. The function of this unit is to drive the turbine through the use of oil.

The impeller is fastened inside the housing and the housing is bolted to the engine flywheel. Consequently, when the engine runs the impeller turns. The blades on the impeller pick up oil present inside the housing. Centrifugal force of the turning impeller forces oil to the outer edge and away from the blades. The oil is thrown against the turbine.



Turbine. Its function is to drive the transmission input shaft.

Oil is forced from the outer edge of the impeller blades and hits the outer edge of the curved blades of the turbine, causing it to turn. The turbine is splined to the transmission input shaft causing the input shaft to turn also. The oil is forced out of the turbine at the center.



Stator. The function of the stator is to redirect the flow of oil from the turbine.

The stator is a stationary member that is mounted on a shaft between the impeller and the turbine. The oil forced from the turbine hits the curved stator blades where the direction of flow is changed. The redirected oil leaving the stator hits the impeller blades, assisting the engine in dirving the impeller.

The action between the impeller and turbine can be compared with the operation of two fans facing each other. With one turned on, the air force from it will hit and drive the blades of the other fan. This is the same principle applied to the torque converter and its operation.

503

QUESTION 30

a. What is the impeller of the torque converter connected to?

b. What member of the torque converter drives the turbine by oil force?

c. What is the function of the impeller of the torque converter?

d. What is the function of the turbine of the torque converter?

e. What is the function of the stator of the torque converter?

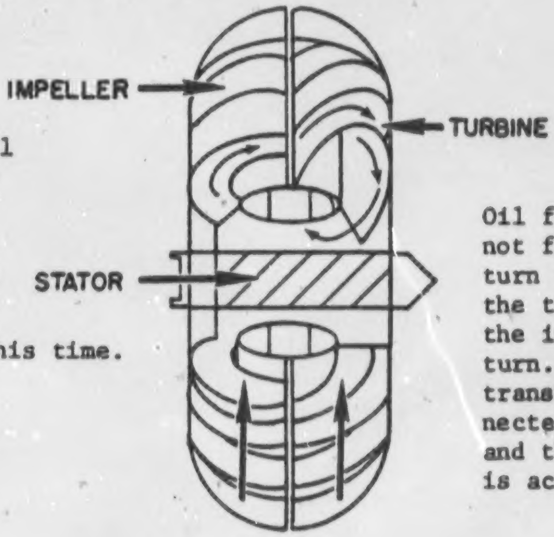
523

ANSWERS TO QUESTION 30:

a. The impeller of the torque converter is connected to the engine flywheel.
b. The impeller.
c. To drive the turbine through the use of oil.
d. Drive the transmission input shaft.
e. To redirect the flow of oil from the turbine.

Frame 42

One of the functions of the torque converter is to act as a clutch, making starting and stopping of the vehicle possible without taking the transmission out of gear. When a vehicle with an automatic transmission is brought to a stop in gear, the engine will naturally be running at idle speed. The action of the torque converter with the transmission in gear and the vehicle stopped is shown in the illustration below.



Turns slowly with engine at idle. Oil thrown from the impeller with very limited force hits the turbine blades.

Inactive at this time.

Oil from the impeller is not forceful enough to turn the turbine. When the turbine stands still, the input shaft does not turn. Therefore, the transmission is disconnected from the engine and the torque converter is acting as a clutch.

QUESTION 31

a. What is the function of the torque converter when a vehicle is brought to a stop with the transmission in gear and the engine idling?

b. Why does the turbine stand still at this time?

505

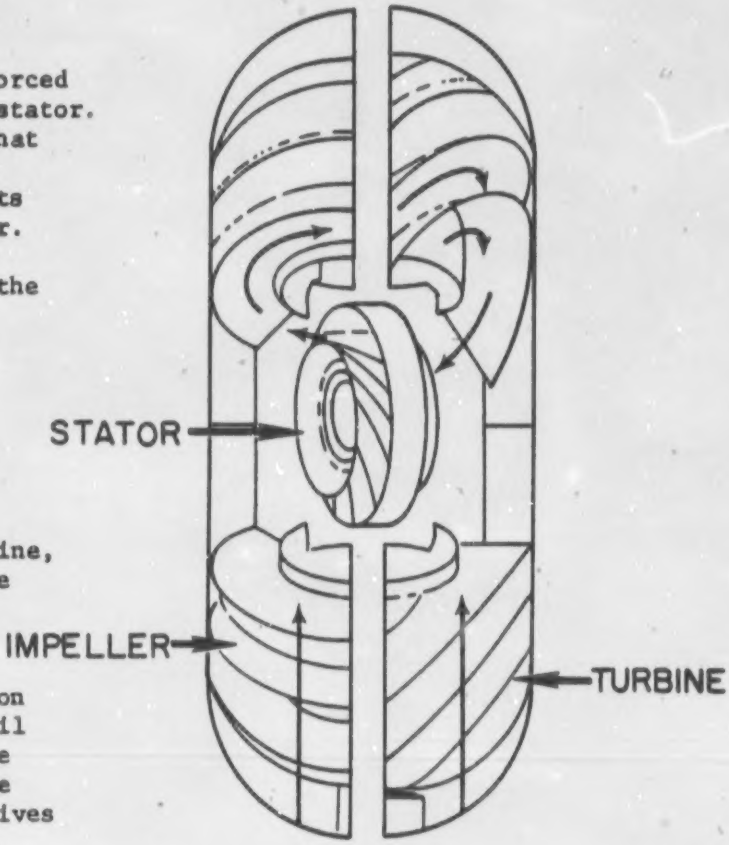
ANSWERS TO QUESTION 31

a. Act as a clutch.
b. Oil from the impeller is not forceful enough to turn the turbine.

Frame 43

The torque converter is capable of performing two other functions in addition to acting as a clutch. The torque converter can transmit torque and increase torque.

OIL FLOW THROUGH TORQUE CONVERTER WITH VEHICLE MOVING.



To increase torque means to increase the amount of twisting force produced by the engine. How does the torque converter increase the torque (twisting force)?

Oil driving the turbine is forced through the curved blades of the stator. The stator redirects the oil so that it hits the impeller blades. Oil hitting the impeller blades assists the engine in driving the impeller. In this way, the torque converter increases the torque produced by the engine.

To transmit torque means to transmit the twisting force from the engine to the transmission. How does the torque converter transmit torque (twisting force)?

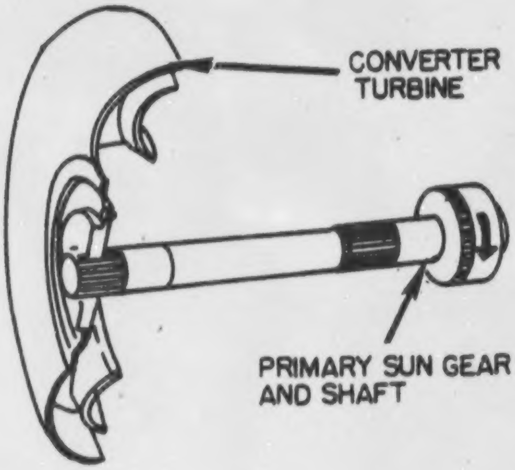
Upon acceleration of the engine, with the transmission in gear, the following takes place. Oil that is picked up by the impeller is thrown against the turbine with great force. (The curved arrows on the illustration above indicate oil flow.) The turbine, turned by the oil, drives the input shaft of the transmission. The input shaft drives gears in the transmission and the vehicle moves.

The torque converter is now transmitting torque from the engine to the transmission.

NO RESPONSE REQUIRED

Earlier in this lesson, we studied the simple planetary gear system. In some two- and three-speed transmissions a different system is used. It is a combination of two simple planetary units and is called a compound planetary gear system. The following illustrations show a breakdown of the construction of a compound planetary gear system used in a two-speed transmission.

In the figure below, the transmission input shaft is illustrated. It drives the primary or input sun gear.



QUESTION 32

What gear is driven by the input shaft?

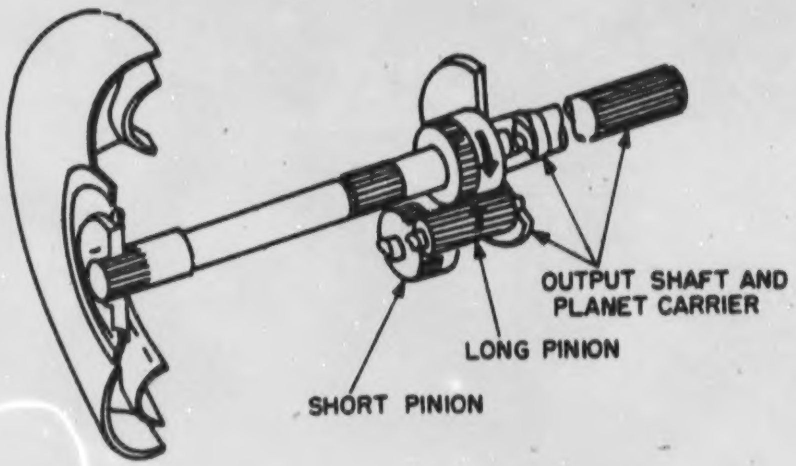
ANSWER TO QUESTION 32

Primary or input sun gear.

Frame 45

The figure below shows the two sets of pinions, and the planet carrier and output shaft. The long pinion is meshed with the short pinion.

Note: There is only one planet carrier in a compound planetary gear system and it is connected to the output shaft in this setup.


OUTPUT SHAFT AND
PLANET CARRIER
LONG PINION
SHORT PINION

QUESTION 33

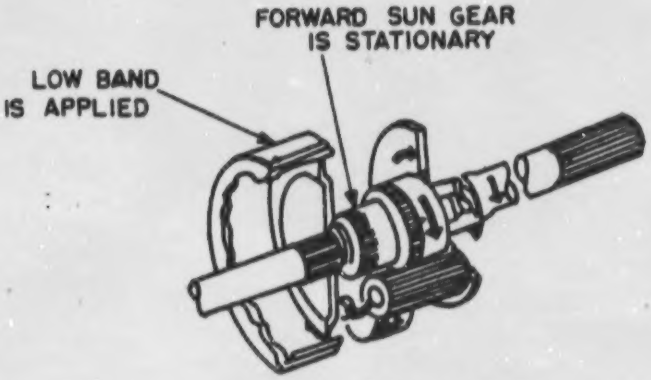
How many sets of planet pinions are used in a compound planetary gear unit?

ANSWER TO QUESTION 33

Two sets of pinions, each set having three gears.

Frame 46

In this figure the forward or low sun gear and flange have been added to the gear set. This sun gear is in constant mesh with the short pinion. Attached to the forward sun gear flange is a drum. Surrounding the drum is a band.


FORWARD SUN GEAR IS STATIONARY
LOW BAND IS APPLIED

FIRST GEAR

QUESTION 34

When low band is applied, what gear is being held?

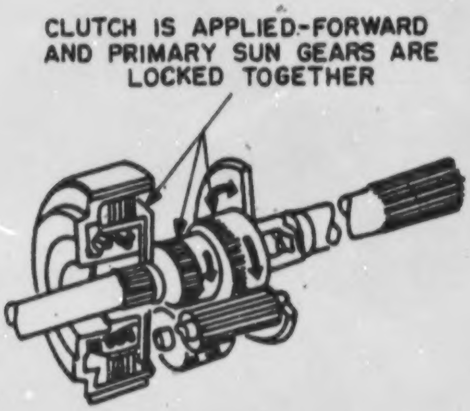
ANSWER TO QUESTION 34

Low or forward sun gear.

Frame 47

In the figure below a clutch has been added to the planetary gear set.

The clutch hub is splined to the input shaft which is connected to the input or primary sun gear. The clutch drum is connected to the forward or low sun gear. When the clutch is applied, the two sun gears are locked together producing direct drive.


CLUTCH IS APPLIED-FORWARD AND PRIMARY SUN GEARS ARE LOCKED TOGETHER

SECOND (HIGH) GEAR

QUESTION 35

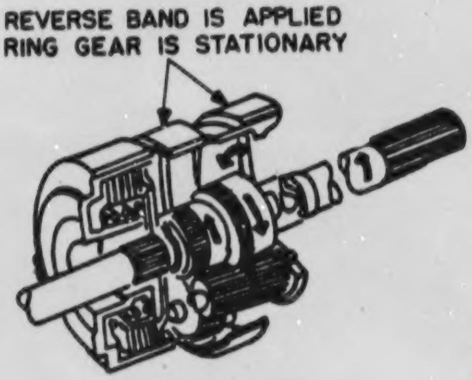
What two gears are locked together for direct drive (high gear)?

ANSWER TO QUESTION 35

Primary or input, and low or forward sun gear.

Frame 48

In the figure below, a ring gear and band have been added. The ring gear is in constant mesh with the short pinion. The ring gear is used for reverse only.


REVERSE BAND IS APPLIED
RING GEAR IS STATIONARY

REVERSE

QUESTION 36

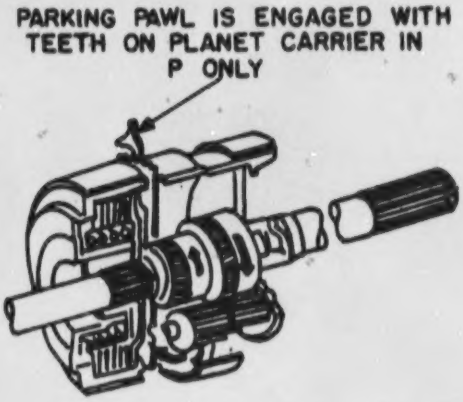
The reverse band holds what gear in order to obtain reverse?

ANSWER TO QUESTION 36

Ring gear.

Frame 49

In the illustration below a parking pawl has been added. The pawl is anchored to the transmission case. When the pawl engages the teeth on the planet carrier, the output shaft is locked to the transmission case. This prevents the rear wheels from turning.

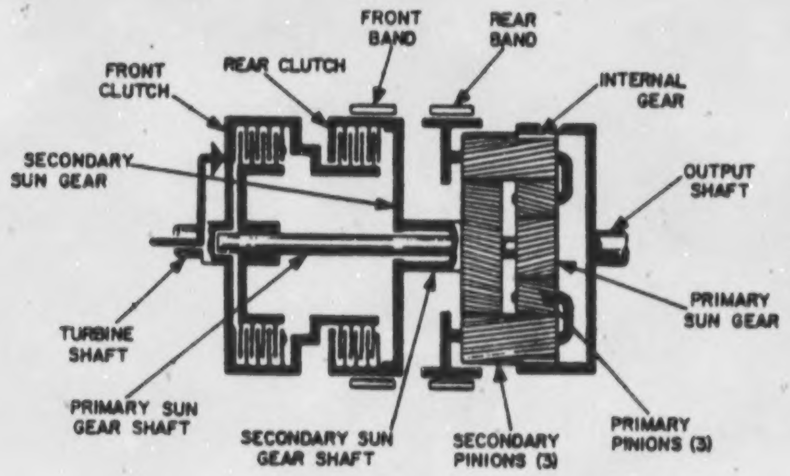

PARKING PAWL IS ENGAGED WITH TEETH ON PLANET CARRIER IN P ONLY

NEUTRAL AND PARK

NO RESPONSE REQUIRED

Frame 50

In the previous frames of this unit you became familiar with the compound planetary gear system used for two speeds forward. The following illustration will point out the construction of a three-speed compound planetary gear system.


FRONT BAND
REAR BAND
FRONT CLUTCH
REAR CLUTCH
INTERNAL GEAR
SECONDARY SUN GEAR
OUTPUT SHAFT
TURBINE SHAFT
PRIMARY SUN GEAR
PRIMARY SUN GEAR SHAFT
SECONDARY SUN GEAR SHAFT
SECONDARY PINIONS (3)
PRIMARY PINIONS (3)

The only difference between the three-speed and the two-speed planetary gear system is that the output shaft is connected to the ring gear in the three-speed; the output shaft is connected to the planet carrier in the two-speed, and the rear band is wrapped around the planet carrier in the three-speed. Also, a front clutch is added to provide neutral and to transmit power to the primary sun gear when applied.

811 513

STUDY GUIDE/WORKBOOK

3ABR47~~330~~232-SW-505

Technical Training

General Purpose Vehicle ~~Repairman~~ Mechanic

BASIC PRINCIPLES
OF
AUTOMATIC TRANSMISSIONS

16 December 1975

USAF SCHOOL OF APPLIED AEROSPACE SCIENCES
3340th Technical Training Group
Chanute Air Force Base, Illinois

Designed For ATC Course Use

DO NOT USE ON THE JOB

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3ABR47330-SW-505

BASIC PRINCIPLES OF AUTOMATIC TRANSMISSIONS

OBJECTIVES

Upon completion of this text, you will be able to accomplish the following with 85% accuracy.

1. Define the terms: torque, reduction, reverse reduction, and direct drive.
2. List the three basic hydraulic principles involved in the operation of automatic transmissions.
3. List the components and their purposes of a basic oil pressure system.
4. In a diagram, label the parts of a simple planetary gear unit.
5. List the three functions of a planetary gear unit.
6. List two rules that apply to the control of a simple planetary gear unit.
7. List the component that holds a member of the planetary gear unit.
8. List the device that is used to control a band.
9. List the component that locks two members of a planetary gear unit together.
10. State how a multiple-disc clutch is applied and released.
11. State the purpose of the governor and what drives it.
12. State the purpose of the throttle valve and what controls it.
13. State the operating principles of the fluid coupling.
14. List the parts of the torque converter and the function of each part.
15. Given a diagram illustrating a two-speed transmission, draw in the flow of main line and variable pressures that will complete the upshift from low to high gear.
16. State the difference between a simple and a compound planetary gear system.

Supersedes 3ABR47330-PT-505, 3ABR47231-1-PT-404B, 3ABR47231A-PT-404B, 3ABR47231B-PT-404B, 3ABR47231C-PT-404B, 18 March 1974.
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DISTRIBUTION: X
TWS - 300; TTVGC - 1

INTRODUCTION

Many variations of automatic transmissions are used on general purpose Air Force vehicles today. However, the basic principles for all units are the same. This lesson will prepare you for following lessons on specific transmissions.

The applicable workbooks for each lesson provide exercises to aid in further clarifying the key points of the lesson. Always follow the directions given by your instructor.

INFORMATION

TRANSMISSION TERMINOLOGY

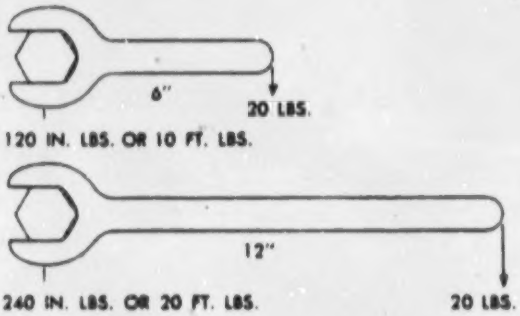


Figure 1. Torque.

Torque

The dictionary defines "torque" as "that which produces or tends to produce rotation or torsion." In other words, torque is a twisting effect. Torque is usually spoken of as pound-foot or foot-pounds. An example is using a wrench. If a 20 pound force is exerted on the end of a six inch long wrench, a torque of 120 inch-pounds or ten (10) foot-pounds will be placed on the bolthead being tightened, as shown in figure 1. If the same force (20 pounds) is applied to the end of a wrench twice as long (1 foot), we will have 20 foot-pounds of torque.

In figure 1, the wrench is used as a lever, and by using longer levers, it is possible to obtain greater torque multiplication. Similar examples can be made with pulleys, block and tackle, inclined planes or wedges and screws. All of these devices actually function on one basic principle. The principle is that if a machine is utilized to increase force, the larger output force cannot move as far as the smaller, original input force. Thus, when force is increased, distance is sacrificed. In thinking of automotive transmissions, the idea of increasing force at a sacrifice of distance means that to increase or multiply torque requires a reduction of speed. If a transmission is required to multiply torque four times, then the input shaft speed in RPM will have to be four times the output shaft speed RPM.

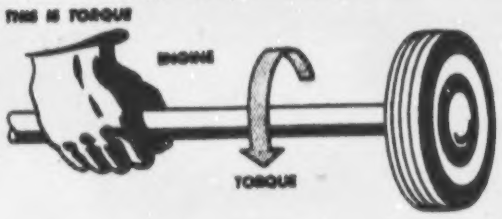


Figure 2. Torque Requirement (Level Ground).

The engine's power is its ability to provide sufficient torque to the rear wheels to maintain certain car speeds. This torque is received from a rotating crankshaft and once a car is rolling on level ground the engine develops enough torque to keep it moving, figure 2.

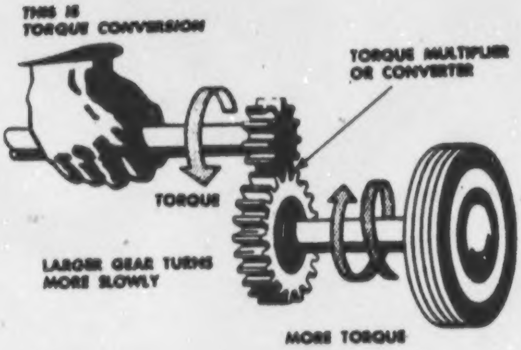


Figure 3. Torque Requirement (Incline).

On a hill or in starting, the driving wheels need more torque and we must have some means of multiplying or converting this torque. This multiplication of engine torque may be accomplished by shifting a gear transmission, either manually or automatically, into a lower gear, figure 3.

Reduction

This term refers to reducing the transmission output shaft speed to increase the output torque, shown in figure 3. This gear reduction is one form of torque multiplication.

Direct Drive

When the vehicle has attained sufficient speed and torque multiplication is no longer required to overcome the resistance of the vehicle to movement, the transmission is shifted to direct drive, which means that the input shaft and the output shaft are turning at the same speed. This is also known as a one-to-one (1:1) ratio.

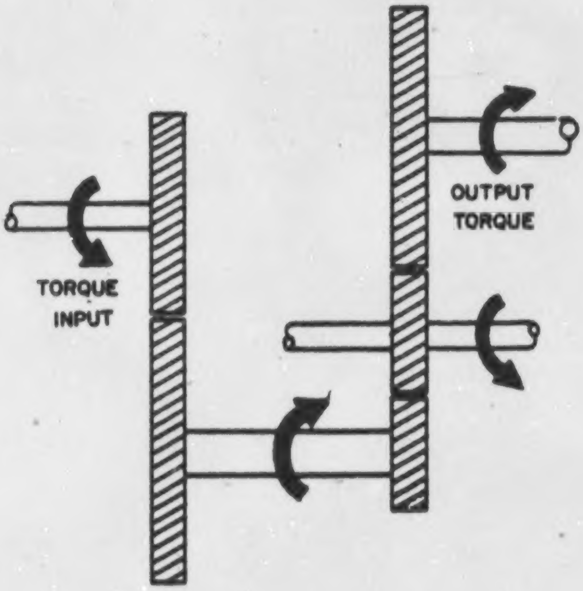


*Figure 4.
Output Shaft Turns Opposite.*

Reverse Reduction

This is an arrangement of gears providing a great amount of torque output in a direction opposite from that of the input as shown in figure 4.

Neutral

When there is an input but no output, a transmission is in neutral.

Overdrive

This is the direct opposite from reduction. The transmission output shaft turns at a speed faster than the input shaft, resulting in torque decrease.

PLANETARY GEAR PRINCIPLES

Planetary gears are used in most automatic transmissions because they permit constant mesh operation in a minimum amount of space and place very little stress on the transmission case.

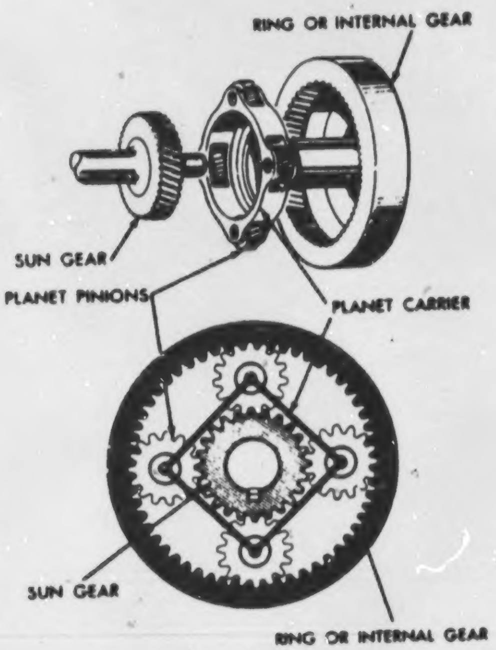


Figure 5.
Planetary Gear Terminology.

In its simplest form, it is essentially three gears, figure 5. There is a sun gear in the center. Also, there is a small planet gear meshing with it. (We show four of them; usually there are three or four.) On the outside is the ring gear, an internal gear meshing with the planets. The planet gears are fastened together by the planet carrier. This holds them in place, but lets them rotate. Just how these gears and carriers are fastened to the shaft depends on what we want the mechanism to do.

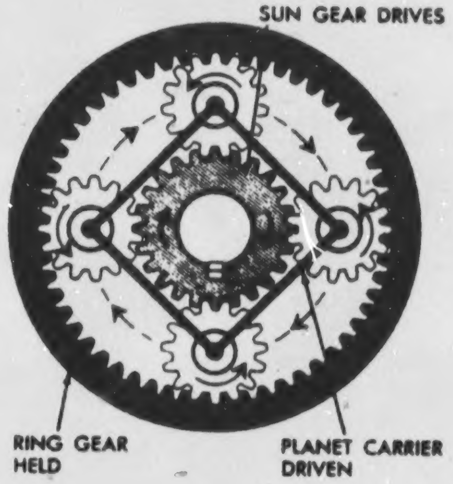


Figure 6. Planetary Gear Maximum Reduction.

Suppose we connect the sun gear to the input, figure 6, or driving shaft and the planet carrier to the output or driven shaft. We put a brake band around the outside of the ring gear and hold it tight so it cannot move. Then, if the engine drives the sun gear, the planet gears must rotate. But they cannot stand still and rotate on their shafts because that would move the ring gear and we are holding that with the brake. So they have to "walk around" inside the ring gear and the planet carrier moves with them at a reduction. There are two motions to the planet gears. Each one is rotating about its own shaft and, at the same time, they are all walking around in a circle on the internal teeth of the ring gear. This is where this type of gear gets its name. The planet carrier is thus the driven shaft, and it is turning much more slowly than is the sun gear and drive shaft and in the same direction. Just what the ratio is depends on the number of teeth on the gears, and we will not go into detail of how it is figured.

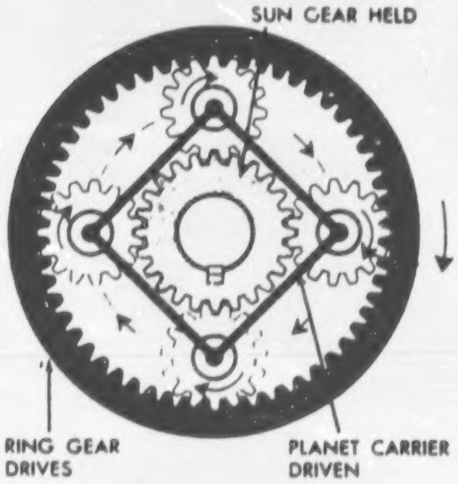


Figure 7. Planetary Gear Minimum Reduction.

We mentioned that we can get various results with a planetary gear set by connecting it up in different ways. If we drive the ring gear and hold the sun gear still, figure 7, we will increase torque as we did in the case just described, but it will not be increased as much.

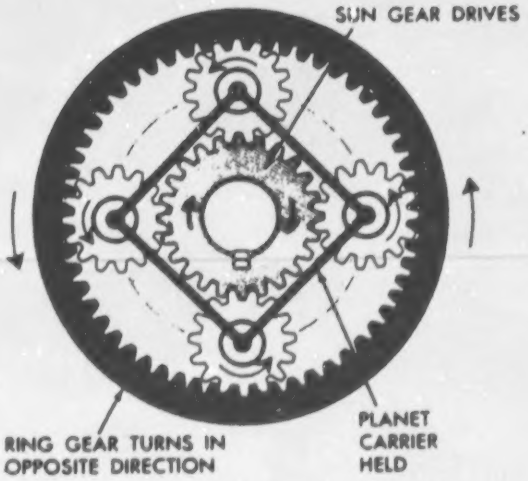


Figure 8. Planetary Gear Train Reverse.

We can also use a planetary gear train to obtain a reversal of direction. If we hold the planet carrier stationary and drive the sun gear, figure 8, the ring gear will be driven in the opposite direction, producing a reversal of rotation with a multiplication of torque.

By other planetary arrangements, it is possible to obtain other gear ratios, such as overdrive and direct drive, and the planetary gears may be compounded, as in transmissions using the torque converter.

From this general description, it is obvious that in order to obtain a drive through a planetary gear train, we must apply power to one member, take our power from another member, and hold a third member still. The driving and driven members are mechanically connected through shafts and hubs to the rest of the transmission.

The member of a planetary gear set that is held is called a "reaction" member because the other members react upon it. This reaction member may be thought of as a point upon which to push, somewhat as a fulcrum point on a lever. There are several automatic transmissions using the compound type planetary gear train, and some using the simple type (the one described in the preceding paragraphs).

HYDRAULIC PRINCIPLES

Before we discuss the hydraulic control of planetary systems, it is necessary to understand the basic hydraulic principles.

Webster's definition of the word "hydraulic" is "the science of liquids in motion and the application of the forces." The laws governing liquids in confined areas are as follows:

1. Liquids cannot be compressed. This rule simply says that applying pressure to liquids will not reduce the volume of the liquid.

2. Motion can be transmitted by liquids. Figure 9 shows two pistons in a cylinder, with a liquid separating them. If piston A is moved to the right, piston B will be moved to the right the same distance. This is due to the rule stated in paragraph 1. Two cylinders of the same diameter are connected by a tube as shown in figure 9, and one piston is contained in each cylinder. If the space between the two pistons is completely filled with liquid, then a movement of piston A to the right will cause corresponding movement of B to the right, with the liquid flowing through the tube.

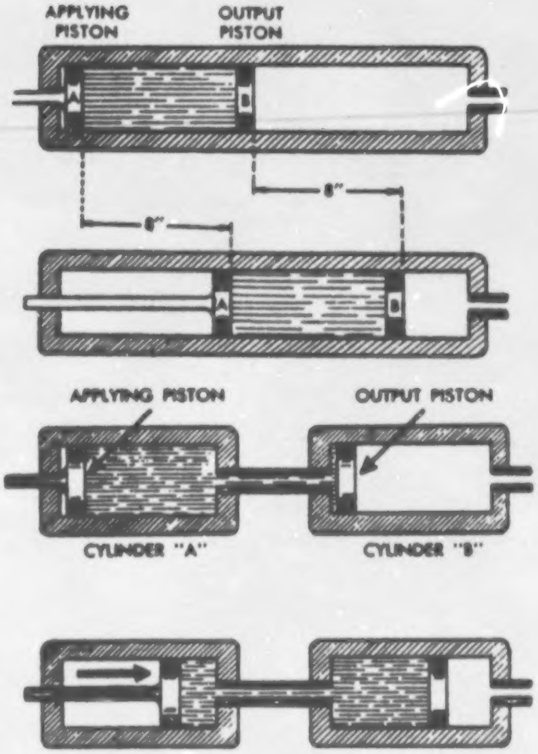


Figure 9. Motion Can Be Transmitted By Liquids.

3. A liquid under pressure transmits pressure equally in all directions. A pressure gage placed anywhere in a closed hydraulic system will read the same at any point, figure 10.

4. Pressure in a closed system, in pounds per square inch (PSI), is the applying force divided by the area of the applying piston. In figure 11 a 100 pound force on a piston of one square inch will produce a pressure in the liquid

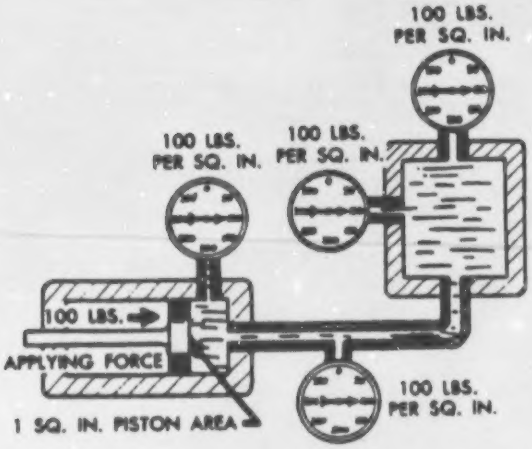

100 LBS.
PER SQ. IN.
100 LBS.
PER SQ. IN.
100 LBS.
PER SQ. IN.
100 LBS.
APPLYING FORCE
1 SQ. IN. PISTON AREA
100 LBS.
PER SQ. IN.

Figure 10. Equal Pressure Through System.

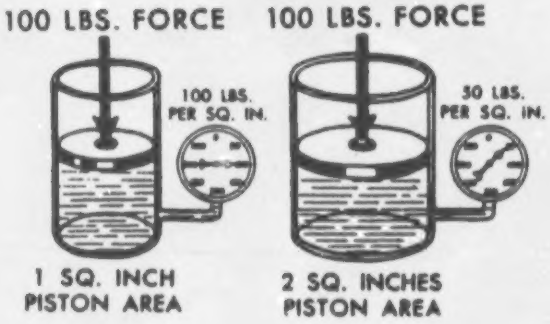

100 LBS. FORCE
100 LBS. FORCE
100 LBS.
PER SQ. IN.
50 LBS.
PER SQ. IN.
1 SQ. INCH
PISTON AREA
2 SQ. INCHES
PISTON AREA

Figure 11. Pressure-Force-Area.

of 100 psi. If this same force (100 pounds) is applied to a piston having two square inches of area, the resulting hydraulic pressure will be only 50 psi. The formula for this relationship

$P = \frac{F}{A}$, where

P = pressure in pounds per square inch

F = force in pounds

A = area in square inches

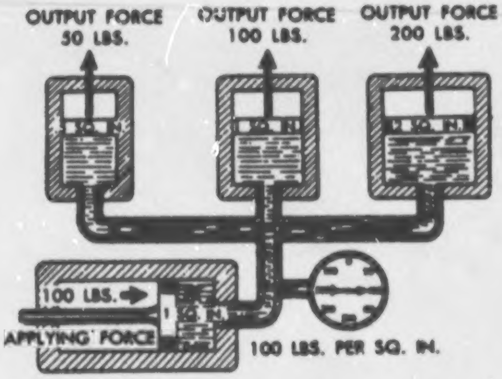

OUTPUT FORCE
50 LBS.
OUTPUT FORCE
100 LBS.
OUTPUT FORCE
200 LBS.
½ SQ. IN.
1 SQ. IN.
2 SQ. IN.
100 LBS.
APPLYING FORCE
1 SQ. IN.
100 LBS. PER SQ. IN.

Figure 12.
Force Output = Pressure Times Area of the Output Piston.

5. Force developed on an output piston is the pressure in the system multiplied by the area of the output piston. Figure 12 shows a 100 pound force applied to a 1 square inch area piston developing 100 psi in a closed system. On piston A, having an area of 1/2 square inch, a force of 50 pounds will be developed. On piston B, 1 square inch area, 100 pounds of force will be developed. On piston C, having an area of 2 square inches, 200 pounds of force will be developed.

PLANETARY CONTROL UNITS

During the discussion of planetary gear sets it was stated that one member of a planetary

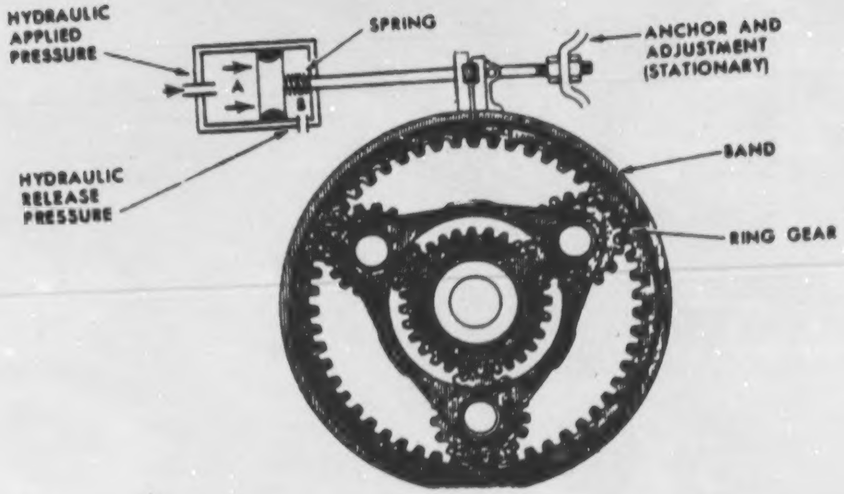

HYDRAULIC APPLIED PRESSURE
SPRING
ANCHOR AND ADJUSTMENT (STATIONARY)
A
B
HYDRAULIC RELEASE PRESSURE
BAND
RING GEAR

Figure 13. Band and Servo.

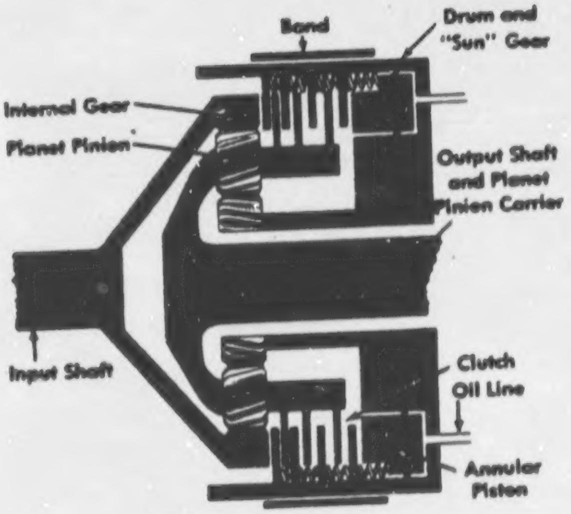

Band
Drum and "Sun" Gear
Internal Gear
Planet Pinion
Output Shaft and Planet Pinion Carrier
Input Shaft
Clutch
Oil Line
Annular Piston

Figure 14. Typical Clutch.

unit must be held to obtain the various reductions, and that to obtain direct drive, two members must be locked together. Hydraulically operated units actuate the friction components to hold or lock the members.

Band and Servo to Hold One Member

A spring steel band with a bonded friction material encircles a drum which, in turn, is attached to a planetary member. Figure 13 shows the drum attached to the ring gear and the servo unit used to actuate the band.

Servo Operation

When hydraulic pressure greater than spring pressure is applied to "A" of figure 13, the piston stem is forced against the band, and the band against the drum. When hydraulic pressure equal to that applied to "A" is applied to "B", the spring is the force that will move the stem and release the band.

Clutch to Lock Two Members Together for Direct Drive

A multiple disc clutch is used to lock the planet carrier and output shaft to the sun gear, figure 14. When no hydraulic force is applied to the piston, the clutch is held in the released position by the clutch release springs. When hydraulic force is applied to the piston to overcome spring pressure, the clutch plates are locked together, which locks the planet carrier and sun gear to the output shaft.

HYDRAULIC OPERATION

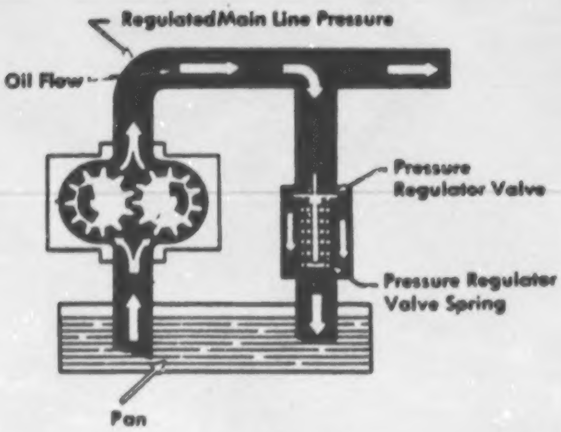


Figure 15. Pump and Pressure Regulator.

Oil Pump and Pressure Regulator

An oil pump, driven by the engine, and a spring-loaded pressure regulator valve are used to provide hydraulic pressure for operation of the transmission. With the pump in operation, oil is drawn from the oil pan and is forced into the hydraulic system. When the oil pressure is greater than the spring pressure in the regulator valve, it will force the regulator valve off its seat and the oil will bypass to the pan. When the oil pressure is less than the spring pressure in the regulator valve, the valve will close and full oil pump pressure will be obtained in the lines, figure 15. This cycle is repeated continuously, and constant regulated "main line" or control pressure results.

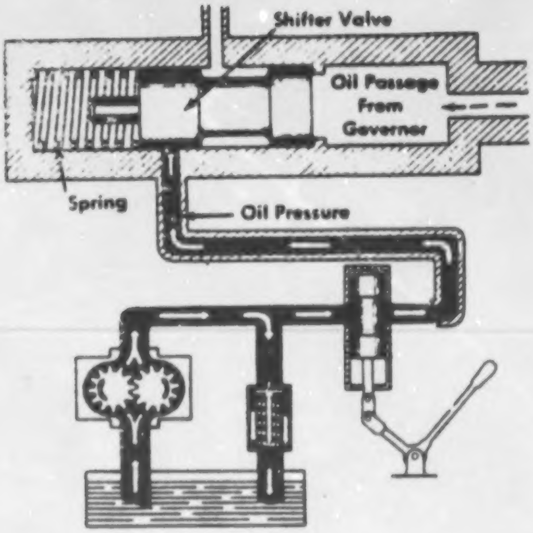

Shifter Valve
Oil Passage From Governor
Spring
Oil Pressure

Figure 16. Manual Valve Open Shifter Valve Closed.

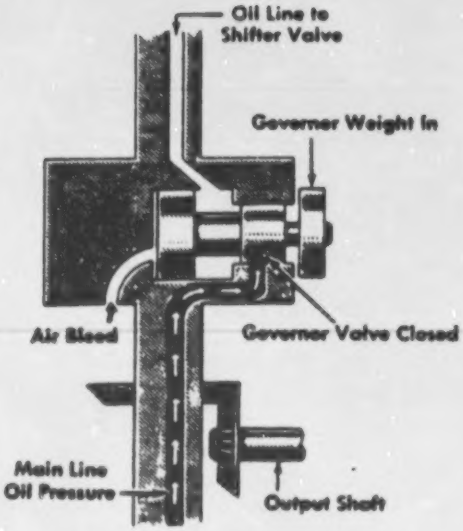

Oil Line to Shifter Valve
Governor Weight In
Air Bleed
Governor Valve Closed
Main Line Oil Pressure
Output Shaft

Figure 17. Governor with Valve Closed.

Manual Valve

A manually operated valve is placed in the main line, figure 16, beyond the pressure regulator to act as a switch to turn pressure on or off.

Shifter Valve

A shifter valve is used to automatically shift from low to direct drive. The valve is opened hydraulically when the oil pressure on the end of the valve is greater than the spring pressure.

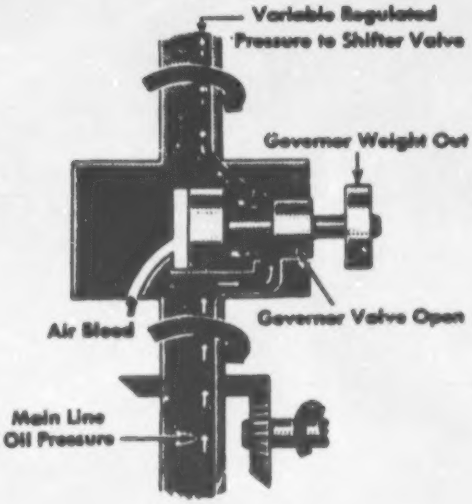

Variable Regulated Pressure to Shifter Valve
Governor Weight Out
Air Bleed
Governor Valve Open
Main Line Oil Pressure

Figure 18. Governor with Valve Open.

Governors (Figures 17 and 18)

The centrifugal governor is driven by an output shaft. Shift from reduction to direct drive is caused by the governor. When the vehicle is standing, the governor weight is "in," closing off the oil passage. As the vehicle moves, the output shaft rotates the governor assembly. As the vehicle's road speed increases, the governor weights are thrown outward, moving the valve and uncovering the oil passage to the shifter valve. Oil passed through this passage exerts pressure against the large area of the valve, acting against centrifugal force. The valve then regulates pressure applied to the shifter valve, which is variable with vehicle speed. As the vehicle's speed increases, centrifugal force increases, moving the valve farther outward and increasing the variable regulated pressure to the shifter valve. This pressure is known as "governor pressure."

Regulator Plug

With the shifter valve, shifter valve spring, and the governor as previously described, shifting from low to direct drive will always occur as the same vehicle speed. This arrangement is undesirable in a vehicle because many circumstances arise when a shift at high speeds is desired. Examples of this are when rapid getaway is desired or when climbing a hill. Need for a higher shift point thus corresponds closely with the need for increased power output of the engine. Since engine power output is controlled by throttle opening which, in turn, is controlled by the accelerator, timing of shift can be regulated with the position of the accelerator. One way of accomplishing this is shown in figure 19. Assume that the shifter valve spring is seated against a moveable regulator plug which is connected to the accelerator. As the accelerator is depressed, the plug is moved inward, compressing the spring and thereby increasing its tension. Because of this increased tension, more governor pressure is required to move the shifter valve; consequently, shift will occur at higher vehicle speeds, as determined by the accelerator position.

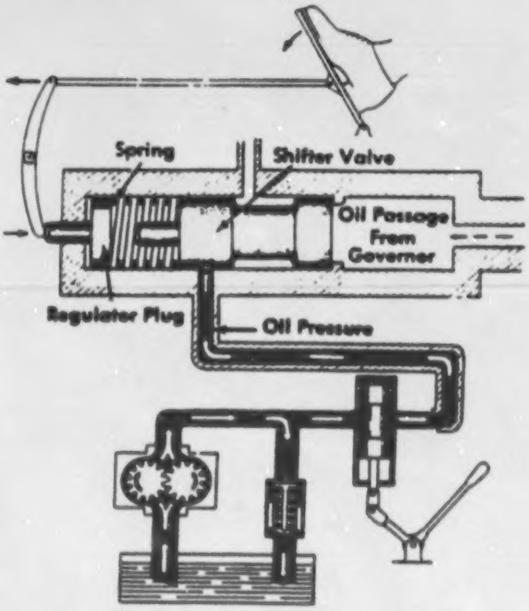


Figure 19. Regulator Plug and Shifter Valve.

OPERATION OF A HYDRAULICALLY OPERATED TWO-SPEED TRANSMISSION

Legend for Schematic Illustrations

→→→ Solid lines with arrows represent passages filled with oil at constant regulated main line pressure.

—— Solid lines without arrows represent passages in which no pressure exists.

- - → ——→ Broken lines with arrows represent passages filled with oil at variable pressure.

---------- Broken lines without arrows represent passages in which no variable pressure exists.

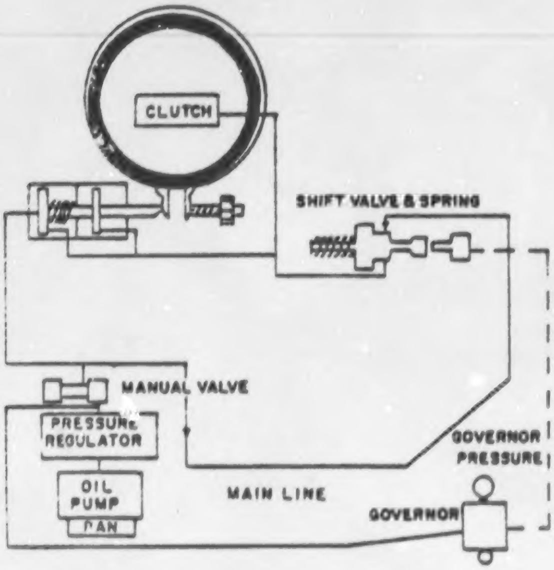
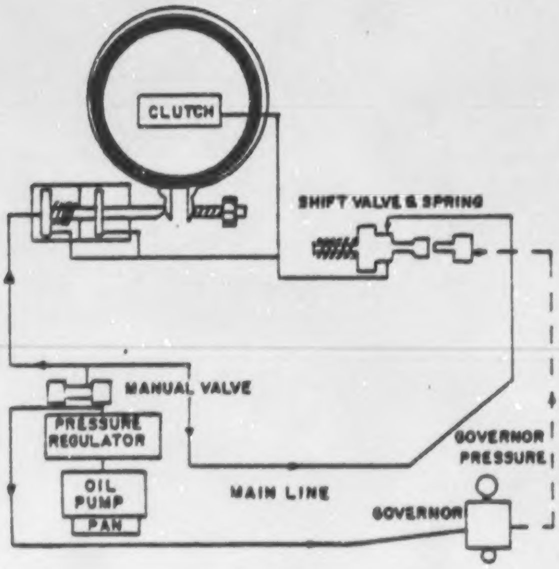

CLUTCH
SHIFT VALVE & SPRING
MANUAL VALVE
PRESSURE REGULATOR
OIL PUMP
PAN
MAIN LINE
GOVERNOR PRESSURE
GOVERNOR

Figure 20. Neutral Engine Running Band and Clutch Released.

Neutral - Engine Running

In neutral the manual valve is closed. The front oil pump, driven from the input shaft which turns with the engine, delivers oil to the pressure regulator and shifter valve. The pressure regulator returns excess oil to the pan, figure 20. The band is released by the spring because there is no oil pressure on the servo piston. The clutch is released by springs because there is no oil pressure to apply to the annular piston.


CLUTCH
SHIFT VALVE & SPRING
MANUAL VALVE
PRESSURE REGULATOR
OIL PUMP
PAN
MAIN LINE
GOVERNOR PRESSURE
GOVERNOR

Band applied - Shift Valve has not moved

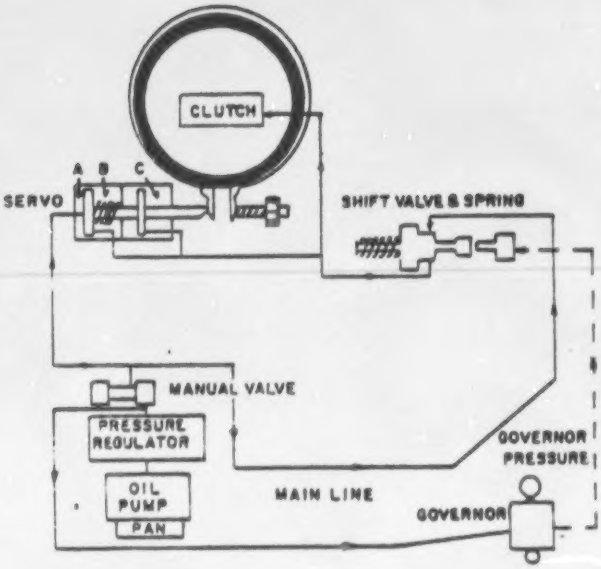
Figure 21. Low Gear.

Low Gear

The manual valve is moved to direct oil pressure to the servo piston and to the band of the closed shifter valve. Oil pressure is also directed to the governor. The servo applies the band and the clutch is released by the springs, figure 21.

High Gear - Direct Drive

A manual valve continues to direct oil pressure to servo piston "A" and to the shifter valve. Governor pressure, due to vehicle speed, has overcome the shifter valve spring pressure and moved the valve so that main line regulated pressure is directed to servo B and C, releasing the band, and to the planetary unit to apply the clutch, figure 22. The transmission will


CLUTCH
A B C
SERVO
SHIFT VALVE & SPRING
MANUAL VALVE
PRESSURE REGULATOR
OIL PUMP
PAN
MAIN LINE
GOVERNOR PRESSURE
GOVERNOR

Shift Valve has moved due to effect of Governor pressure. Clutch is applied. Band released due to pressure operating against two areas ("B" and "C").

Figure 22. Direct Drive.

stay in direct drive as long as the vehicle's speed is sufficient to maintain governor pressure high enough to hold the shifter valve compressed. When speed is reduced to a point where the spring overcomes governor pressure, the transmission will automatically downshift to low. This downshift could be forced by full acceleration at lower vehicle speeds (passing gear) or occur as the vehicle comes to a stop.

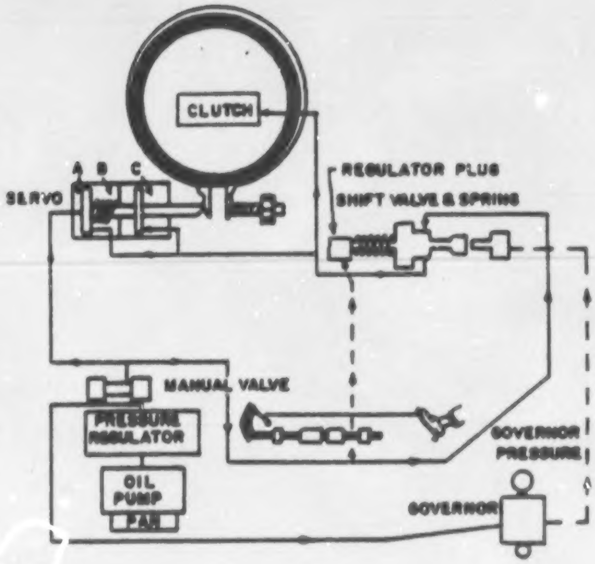

CLUTCH
A B C
SERVO
REGULATOR PLUG
SHIFT VALVE & SPRING
MANUAL VALVE
PRESSURE REGULATOR
OIL PUMP
PAN
GOVERNOR PRESSURE
GOVERNOR

Figure 23. Throttle Pressure to Delay Upshift.

Regulator Plug

The regulator plug in a simple two-speed transmission is moved by a variable regulated hydraulic pressure called "throttle pressure" or "TV" pressure. Throttle pressure is obtained by use of a throttle valve assembly which is moved by mechanical linkage from the accelerator. The valve assembly is so designed that throttle pressure increases with the carburetor opening. Therefore, the farther the accelerator is depressed, the more the shifter valve spring tension is increased to delay upshift, figure 23.

QUESTIONS

1. Define "torque."

2. How is torque multiplied by the transmission?

3. What gears are included in the planetary gear system?

4. Explain the operating principles of the planetary gears.

5. Explain the basic principles of hydraulics.

6. What is the purpose of the "servo" as pertains to automatic transmissions?

7. Explain the operation of the clutch.

8. Explain the operation of the transmission governor.

Vehicle Maintenance Branch
Chanute AFB, Illinois

3ABR47330-WB-505

BASIC PRINCIPLES OF AUTOMATIC TRANSMISSIONS

OBJECTIVES

Upon completion of this workbook, you will be able to explain planetary gear operation and the application of hydraulic principles to a simple two-speed automatic transmission.

PROCEDURE

Complete the following exercises by following the instructions given for each exercise and as directed by your instructor.

Exercise 1

Using figure 24, identify and list in the spaces provided, the components of a planetary gear unit.

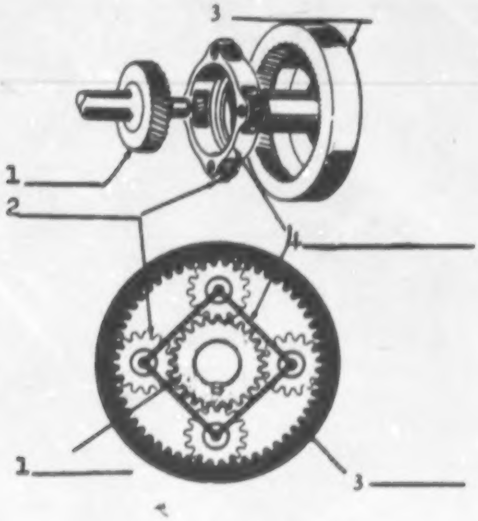


Figure 24. Planetary Gear Terminology.

NOTES

Exercise 2

Using figures 25, 26, and 27, label planetary components as to which member is held, which is driving, and which is driven during maximum reduction, minimum reduction, and reverse reduction.

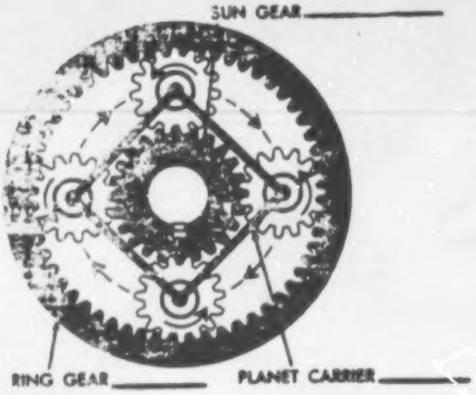

SUN GEAR ________
RING GEAR ______
PLANET CARRIER ______

Figure 25. Maximum Reduction.

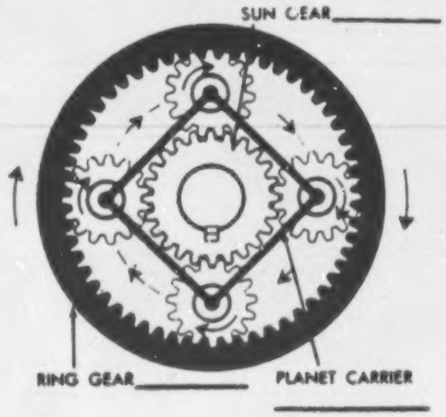

SUN GEAR ________
RING GEAR ________
PLANET CARRIER
____

Figure 26. Minimum Reduction.

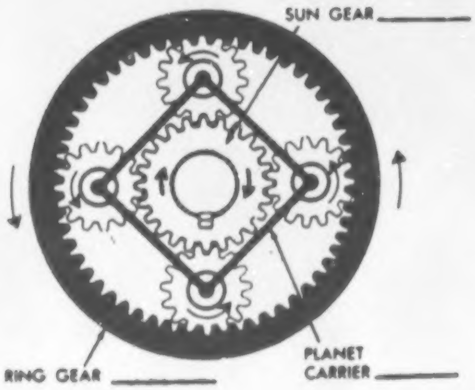

SUN GEAR ______
RING GEAR ______
PLANET CARRIER ______

Figure 27. Reverse Reduction.

NOTES

Exercise 3

Using figure 28, label the components of the simple two-speed planetary gear train in the spaces provided.

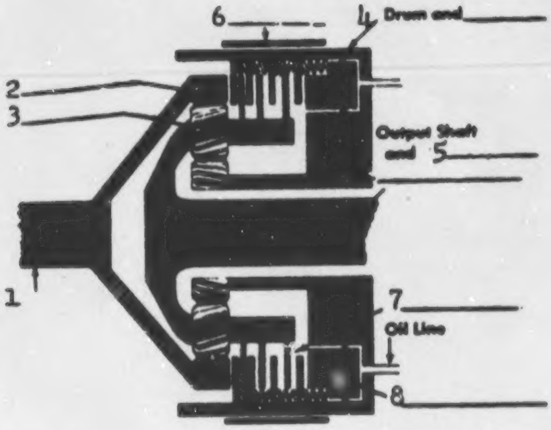

6
4 Drum and
2
3
Output Shaft and 5
1
7
Oil Line
8

Figure 28. Planetary Gear Train of a Two Speed Transmission.

NOTES

Exercise 4

List the purposes of the following components of a simple transmission hydraulic system.

1. Oil pump

2. Pressure regulator valve

3. Manual valve

4. Shifter valve

5. Governor valve

6. Throttle valve

Exercise 5

Using figures 29 through 32, color code the hydraulic schematic drawings as directed by the instructor and using the following colors:

Red - main line pressure

Blue - governor pressure

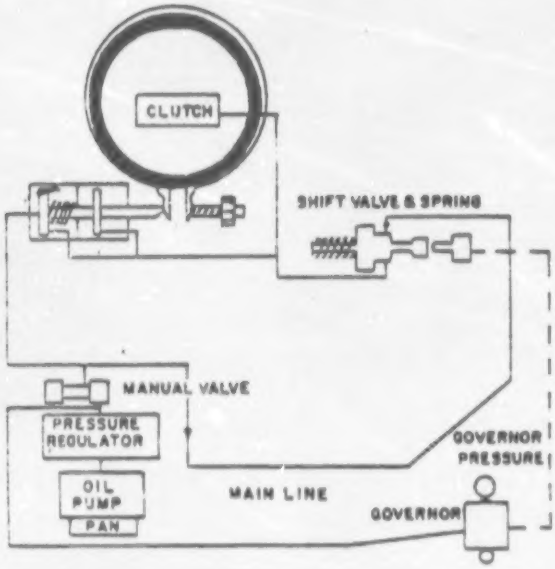

CLUTCH
SHIFT VALVE & SPRING
MANUAL VALVE
PRESSURE REGULATOR
OIL PUMP
PAN
MAIN LINE
GOVERNOR PRESSURE
GOVERNOR

Figure 29. Neutral Engine Running Band and Clutch Released.

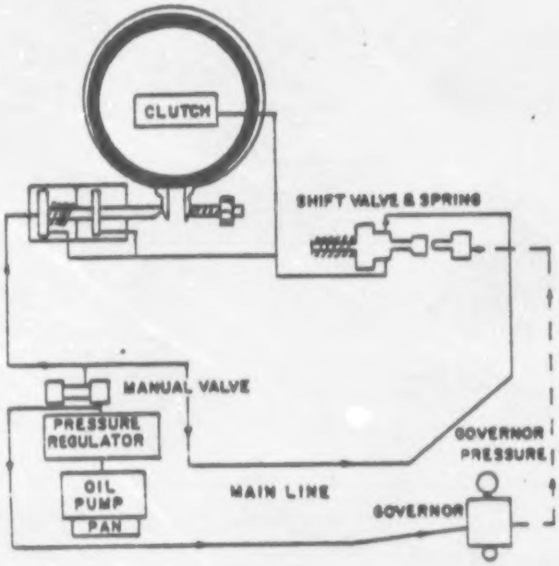

CLUTCH
SHIFT VALVE & SPRING
MANUAL VALVE
PRESSURE REGULATOR
OIL PUMP
PAN
MAIN LINE
GOVERNOR PRESSURE
GOVERNOR

Figure 30. Low Gear.

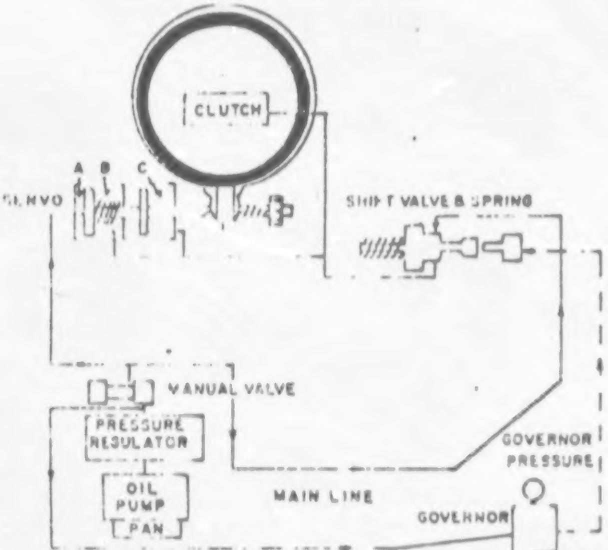

CLUTCH
A
B
C
SERVO
SHIFT VALVE & SPRING
MANUAL VALVE
PRESSURE REGULATOR
OIL PUMP
PAN
MAIN LINE
GOVERNOR PRESSURE
GOVERNOR

Figure 31. Direct Drive.

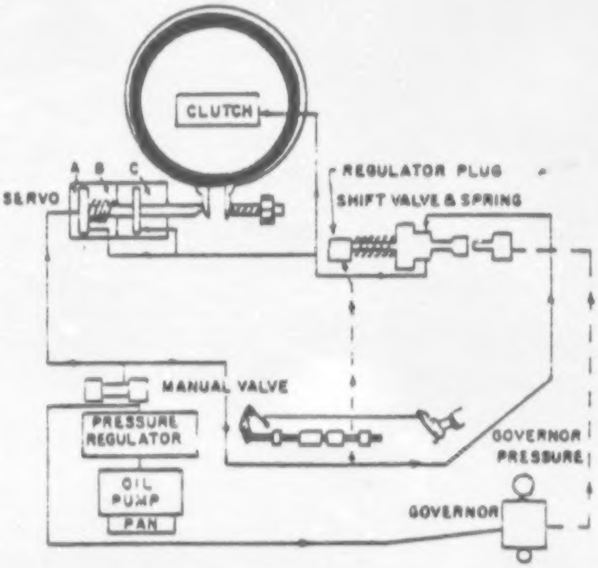

CLUTCH
A
B
C
SERVO
REGULATOR PLUG
SHIFT VALVE & SPRING
MANUAL VALVE
PRESSURE REGULATOR
OIL PUMP
PAN
GOVERNOR PRESSURE
GOVERNOR

Figure 32. Throttle Pressure to Delay Upshift.